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A FOREWORD.

By SIR A. DANIEL HALL.

When an investigator has completed his work his results possess little value to anyone but himself unless they can receive adequate publication and become known not merely to people engaged in the same sort of work but also to a wider public who are in a position to make use of it. Publication is so far recognised as essential to research that the older societies which were formed for the promotion of science, as for example our own Royal Society, devoted the greater part of their funds to producing a Journal of some sort which would print such researches as the Society thought worthy of dissemination. As science developed it became impossible to cover the whole domain by one publication, and specialist societies grew up each with their own journal—Chemists, the Botanists, the Geologists—devoted to this particular branch of science. Specialisation has however grown to such a degree, especially with the influx of research on technical subjects, that a more extended publication was called for. In some cases this demand has been met by the formation of societies of even more strictly limited interest, but in the field of Agriculture and Horticulture where research work is mostly undertaken by *ad hoc* institutions it has become customary for each institution to publish its investigations by means of an Annual Report. The drawback to this method is the obvious mechanical one of the multiplication of periodicals of very unequal value. The worker with a library at command has great difficulty in finding what has been published, while the ordinary practical man who wants to keep in touch with investigation cannot cope with the volume of literature that is issued. Good work may thus get printed and yet is never published at all in that it never reaches more than the most limited public. For real publication there must be an authoritative source, responsible for both the collection and selection of the material to be printed.

"The Journal of Pomology and Horticultural Science" is an attempt to supply such an authoritative source for all the investigation and new work that is being done in connection with fruit growing in Great Britain.

We see at the present time a great renaissance in fruit growing in this country. It is not merely that its commercial importance is increasing at a rapid rate, but the whole industry is alive and active in improving its methods. Commercially we see the interest that is being put into questions of grading and packing, technically the growers are awake to the fundamental importance of producing only the best varieties, of improving the cultivation, of dealing with disease. There is still all too large an acreage of neglected orchard that

produces fruit of a sort when conditions are favourable, but every year sees an increase in plantations managed with skill and knowledge that can meet the competition of any country.

But the most modern grower has his difficulties and needs knowledge as a means of coping with them, which knowledge is not only the product of experience but depends upon the results of investigation. The means for investigation have now been provided in England ; within the last ten years have been founded research stations at the Fruit and Cider Institute at Long Ashton, near Bristol, at the Horticultural Research Station at East Malling, Kent, and at a further Horticultural Institute in connection with the University of Cambridge. There are other agencies like the John Innes Horticultural Institute, the Lea Valley Research Station, the laboratories and gardens of the Royal Horticultural Society at Wisley and of University College, Reading, while many of the great commercial firms who have been at the back of the progress made by British Horticulture in the past have knowledge and experience that they are willing to share with the members of the industry they serve. " The Journal of Pomology and Horticultural Science " is intended to be the means of bringing together the information gathered from all these sources, of interchanging it with other workers, and particularly of passing it on to the public that can make use of it and translate it into practice—the working fruit growers of the country.

Technical Investigation is only fruitful if it keeps in touch with practical men ; they know where the shoe pinches, they can supply the suggestions and criticism upon which the investigation works, and they can exchange information as to the methods by which research is put into action.

The Journal has already been in existence for some time, having been started and maintained by the sole energies of Mr. E. A. Bunyard. The financial responsibility is now being taken over by the three research institutes mentioned above but Mr. Bunyard has agreed to continue his work as Editor. While " The Journal of Pomology and Horticultural Science " will naturally be the medium for the publication of the results of the investigations conducted at the three institutes, investigations, the practical utility of which has already been widely recognised, it is hoped that it will also gather together new knowledge and experience from all kinds of public and private workers connected with fruit growing in Great Britain. Progress is determined by knowledge, by discussion, by stimulus ; we know the fruit growing industry is alive with enthusiasm and energy, the aim of the " Journal of Pomology and Horticultural Science " is to see that such enthusiasm and energy is directed to the best ends and is armed by all the help that science can give it.

AN INTRODUCTORY NOTE ON THE HISTORY AND DEVELOPMENT OF THE RASPBERRY.

By EDWARD A. BUNYARD, F.L.S.

The wild Raspberry (Rubus Idaeus) is generally found in Europe and extends throughout Northern Asia, and, if we may believe Pliny, it owes its Latin name to its abundance on Mount Ida in classic days. Botanists have recognised several varieties of R. Idaeus, such as vulgatus, denudatus, angustifolius, maritimus, semperflorens, luteo-fructifer, obtusifolius, etc., but in a species with so wide a range, variation would be expected, and the horticulturist would accept them as the usual seedling divergencies. It is doubtful if the " upright and tall growing " Rubus mentioned by Theophrastus is a Raspberry, as he and most early writers confuse it with the Blackberry. It is probable that in any case it was not cultivated in these days, as even the later authors, Athenaeus, Theocritus and Virgil do not mention it, though a medicinal reference to the " batus idaea " is to be found in Dioscorides. A mention in Palladius (I., 34) quoted by some writers refers to Rosa canina, and not the Raspberry.

Pliny is the first author who gives a full reference to the Raspberry as a garden fruit, and his information is obviously based on Dioscorides.

It is only when we come to the sixteenth century that we find the Raspberry a cultivated fruit, and Ruellius reports it " everywhere cultivated in gardens," and Matthioli, in whom we find so many early accounts of our fruits, speaks of it being taken from woods to gardens in Bohemia.

A yellow variety is recorded by Clusius (1601) and a white variety is also spoken of by Canerarius (1588). The early German Herbals such as the Gart de Gesuntheit (1485) figure a fruit which might equally be a Blackberry or a Raspberry.

The early French agricultural writers seem to know only the Red and White (or Yellow), and it is necessary to come to English gardens to find any real interest in this fruit, just as in the late eighteenth century it was in this country that the first garden sorts were raised.

Definite evidence of garden culture is supplied by William Turner in his " Names of Herbes " (1548), " Rubus Idaeus in Englishe raspes or hyndberries . . . grow most plenteously in the woddes in East Friesland . . . They also grow in certayne gardines in Englande. . . . The taste of it is soure."

When we come to the early years of the seventeenth century we find a definite number of varieties grown, and Parkinson (1629) gives a good description of these in his inimitable style: "The Raspis-berrie is of two sorts, white and red, not differing in the forme either of bush, leaf or berry, but onely in the colour and taste of the fruit. The Raspis bush has tender white stemmes with reddish small prickles like hairs set round about them, especially at first when they are young, but when they grow they become more wooddy and firme, without any shows of thorns or prickles upon them, and hath onely a little harinesse that covereth them. . . . There is another whose stemme and branches are wholly without prickles, the fruit is red and somewhat longer and a little more sharpe."

This extract well shows the extraordinary observation of Parkinson, his description of the young growing canes cannot be bettered.

In Tradescant's catalogue (1656) we find these three varieties and a fourth variety, purpureo, which may be a darker coloured red Idaeus.

Batty Langley (1729) has the same varieties, but in Switzer (1724) we first meet a *large* Red Garden variety, which is the first record I have found of any increase in size.

In the "Treatise of Fruit Trees" of Thomas Hitt, we find six kinds, the common small red and white and two other sorts much larger called "rombullions," a name we now know as applied to two sorts of Gooseberries.

He also adds two other sorts called the "Dedingen" red and white, double bearers but with small fruit.

In the early years of last century we come into a period of new Raspberries raised from seed, some of which are still grown at this time.

The Brentford Raspberry was largely in favour until the Red Antwerp was raised by Mr. Cornwall, of Barnet, probably about 1800, and this according to Rogers, "took the lead of all others."

The Yellow Antwerp had been introduced by a Mr. North, of Lambeth, from Belgium some years before, and was the reason of the name Red Antwerp being given to the English variety, but there seems no doubt that it was raised by Cornwall. To the same gardener we owe the Barnet, a variety which Rogers says "has some advantage over the Red Antwerp in point of size, but in nothing else." A little later (1825) the Fastolf was raised by Col. Lucas, of Filby House, Yarmouth.

The history of the Raspberry thus briefly sketched out shows, as do many other fruits, a long period of cultivation before any new garden varieties arise, and the sudden appearance of giant forms which are accepted at once as a great improvement upon existing varieties. In recent days Superlative occupied such a position for many years, only to be superseded by Royal, which is now recognised as the largest variety in cultivation.

A NOTE ON THE IMPURITY OF RASPBERRY STOCKS.

By N. H. GRUBB.

East Malling Research Station.

AND

G. S. PEREN.

University of Bristol Research Station, Long Ashton.

The question of the nomenclature of Raspberry varieties has been approached by both the Long Ashton and East Malling Research Stations, but from a slightly different angle. At Long Ashton it was decided to obtain each variety from a large number of sources with a view to discovering the real extent of any confusion that might exist, and at the same time to collect every variety obtainable from nurserymen. Most of the varieties at Long Ashton thus came from nurserymen ; a few new sorts were obtained from the raisers. At East Malling the intention was to sort out and describe all the varieties grown commercially ; with this in view canes were obtained mainly from market growers, with a few supposedly standard sorts from nurserymen. At the same time many well-known Raspberry districts were visited from East Malling, and notes made on the spot regarding the varieties grown and the names used ; visits were paid to growers in Kent, Surrey, Essex, Cambridgeshire, Norfolk, Worcestershire, Hampshire, Devonshire, and Perthshire. Both Stations have concentrated on Summer red-fruited varieties, as being of chief commercial importance.

Whilst neither collection is yet complete, it seems quite certain that no commercially important British varieties are omitted from both, and that a joint summary of the relation between varieties and names will give a fairly accurate view of the existing position in regard to nomenclature.

Before we proceed to tabulate the information so far obtained, it may be of interest to suggest two or three possible causes of the existing confusion. The transference of a name from one variety to another and the dissemination of the wrong variety under the name, are undoubtedly important factors ; but if this were the only cause of the confusion it would surely have been possible by now to discover alternate names, for example, for some of the five or six varieties known to us only as " Red Antwerp."

Another factor which seems likely to have contributed largely is the growth of seedlings from the seeds of fallen fruit. This is undoubtedly a common cause of the presence of rogues in many varieties ; that it is not the chief cause,

however, is shown by the fact that, of eighteen rogues isolated from samples of Raspberries received at East Malling, eleven were definitely identified as named varieties; one stock of "Profusion," as received, contained four distinct rogues, of which three were named varieties.

Where a variety normally produces few canes, the growth with it of rogues which normally produce very many canes will naturally tend to suppress the true variety. This actually occurs with Superlative and Norwich Wonder; in many soils these varieties produce few canes, and both are often mixed with rogues (named or nameless) which produce very many canes; we have seen plantations of both these varieties where the canes of the true variety constituted but a small proportion of the whole. Many of these rogues are undoubtedly self-sown seedlings; it is clearly to be expected that any of them which happen to have commercial value may be propagated and disseminated under the name of the variety amongst which they occur.

A third possible cause of the confusion, which many growers believe to be very common, is the production of new forms through "bud sporting" from the roots. Although one or two possible examples of this have been seen at East Malling, we have not yet discovered a case where it has been widespread enough to cause any confusion. The common "degeneration" of certain varieties may perhaps be due to this factor. The most probable case is that of "Kirriemuir Fillbasket," formerly grown for market in Perthshire and elsewhere, and now largely abandoned on account of its "degeneration." But even this case requires close study before we can ascribe the trouble to "bud sporting."

Table I. shows the number of distinct varieties found to be grown under the various names; it is considered here that any variety constituting fifty per cent. of the plants in a plantation may be regarded as grown under the name given.

TABLE I.—NUMBER OF VARIETIES GROWN UNDER EACH NAME.

Name given.	*No. of Varieties.*
Antwerp, Black	2
Antwerp, Red	8
Baumforth's Seedling	8
Carter's Prolific	3
Fastolf	4
Fillbasket	7
Hornet	7
Laxton's Bountiful	2
Norwich Wonder	3
Profusion	2
Pyne's Royal	3*
Red Cross	2
Semper Fidelis	3
Superlative	5

* Of these, one was Red Cross, the names having obviously been transposed by the grower; this also accounts for the second variety under the name "Red Cross."

Under other names only one variety was found for each ; the most important of these are Bath's Perfection, Devon, and Mitchell's Seedling.

It should be noted that still other varieties were often found growing as rogues under several of these names ; in some cases it would be impossible to state the number of these rogues—such varieties as Hornet (A) and Superlative having frequently very many kinds of rogues mixed with them.

Whilst all the fourteen names given in Table I. were applied to more than one variety, in several cases the same variety was found to occur under more than one name. Here again varieties constituting fifty per cent. or more of the plants in a plantation are regarded as grown under the names given.

Table II.—Varieties Grown under More Than one Name.

(The variety names here used are those given in " Commercial Raspberries and their classification " in this issue.)

Variety.	*Names given.*
Bath's Perfection ..	Bath's Perfection many times. Superlative three times (in one case 30 per cent. were true Superlative). Baumforth's Seedling twice. Hornet twice. Red Antwerp once. Abundance three times. Marlborough (from U.S.A.) once. (Of these names Abundance and Marlborough are recognised synonyms for Bath's Perfection.)
Baumforth's Seedling B..	Baumforth's Seedling many times. Hornet once. Semper Fidelis once. Fillbasket once. Red Antwerp once. Fastolf twice. Superlative once.
Hornet A. ..	Hornet many times. Baumforth's Seedling once. Norwich Wonder once (here 20 per cent. were true Norwich Wonder). Superlative once.
Red Antwerp B. ..	Red Antwerp several times. Carter's Prolific once. Norwich Wonder once.
Norwich Wonder ..	Norwich Wonder many times. Fillbasket twice. Laxton or " Laxton's Fillbasket " twice (both in Perthshire).
Black Antwerp A. ..	Black Antwerp several times. Red Antwerp several times. Late Antwerp once.

Variety.	*Names given.*
Red Antwerp A.	Red Antwerp several times. Black Antwerp several times. Early Antwerp once.
Red Antwerp F.	Red Antwerp twice (from same source). Black Antwerp once.
Baumforth's Seedling C.	Baumforth's Seedling twice (from same source) Hornet five times.
Hornet B.	Hornet once. Fastolf once (probably).
Mitchell's Seedling	Mitchell's Seedling several times. Profusion once.
Red Cross	Red Cross several times. Royal twice.
Pyne's Royal	Royal many times. Red Cross twice.
Superlative	Superlative many times. Devon once.

Some of these varieties also occur as rogues (less than fifty per cent. of the plants) under still other names. In some cases no one variety constituted as much as fifty per cent. of the plants ; and in one case ten plants were found to include at least four and possibly five varieties.

We thus find that even where a certain name (e.g. " Bath's Perfection ") is applied to only one variety, the same variety may actually be grown under several other names ; it seems that nearly all growers of Raspberries know what to look for under the name Bath's Perfection, but they fail to recognise the same variety under another name.

The presence of rogues in many samples has already been mentioned. The newer varieties are, of course, usually free from rogues, though even these are sometimes found to include a small percentage of other varieties. Bath's Perfection, in particular is rarely sent out, even under another name, with any appreciable proportion of rogues ; the variety (Bath's Perfection) does sometimes occur as a rogue amongst others, but even this is uncommon. Of twenty-one samples received at the two stations as " Bath's Perfection," every one was true to name and free from rogues. Of other varieties received from ten or more sources, Superlative was the only one of which as many as fifty per cent. of the samples were true to name and free from rogues.

From the number and character of these instances of confused nomenclature we can draw but one conclusion : that the greatest possible care is called for in obtaining Raspberry canes for planting, to make sure that the variety is actually the one desired, and that it is not mixed with a large proportion of rogues.

COMMERCIAL RASPBERRIES AND THEIR CLASSIFICATION.

By N. H. GRUBB, M.S.A.

East Malling Research Station.

The identification and description of varieties of Raspberries has been taken up at this station as a necessary preliminary to an intended investigation of the effects of artificial manures on the quality of the fruit. For the latter purpose a collection of Raspberry varieties was obtained from various sources in the winter of 1916-17. By the summer of 1919 it was evident that several of the varieties contained a number of rogues ; and there was reason to believe that one or two of them were not the sorts commonly grown under the names given. It was therefore found necessary first of all to obtain true strains, correctly named, of all the varieties intended for future investigation.

The examination of commercial plantations of Raspberries led to the conclusion that there was a somewhat widespread confusion of nomenclature, and it was therefore decided to make as complete a collection of commercial varieties as possible. For this purpose a number of varieties has been added to our collection ; although not yet complete, the collection is now considered extensive enough to justify the issue of a first report. It has been possible, through the kindness of Raspberry growers in many places, to check and amplify many of the descriptions made at East Malling from plants growing in widely different conditions, and to add tentative descriptions of varieties not yet established here. The writer wishes to express his thanks to the growers who have so kindly helped him in this way.

The vital importance of a uniform and recognised system of nomenclature is perhaps even now hardly realised. The economic value of the varieties is widely different, as regards both adaptation to local conditions and suitability for various purposes. Some varieties seem to be of small value in any conditions, while a few are largely indifferent to local conditions and of high value almost anywhere ; the majority are excellent in some conditions and poor in others. These differences, unfortunately, are often very marked among varieties grown under the same names. Of the six varieties known as " Red Antwerp," for example, one is almost worthless wherever it has been seen, while at least one other appears to have rather special requirements in regard to soil.

The cropping capability of ten varieties has now been tested in our soil for four consecutive years ; the comparative results are shown below. Note

particularly the wide difference in our conditions of the two "Baumforth's Seedlings" included in the table.

	Average 1919-1922 inclusive.
Taking Pyne's Royal as	100
Baumforth's Seedling B cropped	85
Profusion (Bunyard's) ,, ...	73
Devon ,, ...	69
Norwich Wonder ,, ...	64
Bath's Perfection ,, ...	60
Baumforth's Seedling C. ,, ...	58
Superlative ,, ...	42
Hornet B ,, ...	39
Park Lane ,, ...	33

It must be clear from these figures that the use of names interchangeably will inevitably lead in many instances to heavy loss.

It may be said at once that most of the newer, as well as some of the older, varieties of Raspberries are usually correctly named and tolerably free from rogues. The confusion arises chiefly in the naming of certain older varieties. We find among Raspberry varieties both the causes of confusion found in the earlier work at this Station among varieties of Black Currants. Synonyms, the use of more than one name for a certain variety, are of fairly common occurrence amongst Raspberries; and still more common is the existence of several varieties under one name. But here a difficulty arises which was not found amongst Black Currants, *i.e.*, the existence of several obviously distinct varieties, in true strains, under one name, and the apparent non-existence of other names for most or all of them. So far has this gone, that we shall be compelled temporarily to speak (for example) of Red Antwerp A, Red Antwerp B, etc.; it is hoped that the history of some at least of these varieties may eventually be discovered, and possibly the use in some places of alternative names. But in the absence of detailed published descriptions it will be extremely difficult to judge which of the several varieties is best entitled to the name.

The confusion in the names of Raspberry varieties and suggested causes of it are shown in some detail in the joint note from the Long Aston and East Malling Research Stations in this number, entitled "A Note on the Impurity of Raspberry Stocks."

Characters Most Useful for Identification.

Although there is no unusual difficulty in learning to recognise Raspberry varieties by means of their vegetative characters, it is far from easy to pick out the points used semi-consciously for identification, and still more difficult to make any adequate written description which will enable others to identify the same varieties. Almost all the possible characters are so extremely unstable,

and so strongly affected by local conditions, that one is often unable to be sure of the identity of a certain variety unless one can find a known variety growing in the same conditions with which to make a comparison. And most varieties, even in a few yards length of a single row, will usually show extremely wide variation in several important characters.

After four years of close study it has been found that the surest means of identification are provided by the young growing canes during June, July and August. The fruit is often useful while it lasts, as are also certain characters of the fruiting canes ; taken in conjunction with the characters of the new canes, these will, in many cases, provide a final test.

Of all the characters of the new canes, only one has so far been found to remain quite constant in all conditions of growth. This, the presence or absence of a dense growth of fine hairs (" pubescence ") on the surface of the new cane, enables us to separate all varieties into two main groups. The pubescence is best seen within a few inches of the growing point at any time while growth is rapid ; if the cane is not pubescent (" glabrous "), its surface in this region is very shiny, while if pubescent, it is dull. On the lower part of the cane the distinction is less obvious, owing to the fact that the bark of most glabrous varieties soon becomes glaucous (covered with waxy secretion).

It should be noted that few varieties produce new canes entirely glabrous throughout their length ; several of those regarded here as " glabrous " have actually a number of scattered hairs near the growing point, especially on the ridge below the petiole, and these hairs tend to become more numerous towards the end of the season, especially when growth is continuous. But the distinction between this type of pubescence and the type called here " pubescent " is quite unmistakable.

It is curious that this distinction is not carried over to the shoots of the fruiting canes. So far as the writer has discovered, all varieties produce pubescent shoots from the old canes, and any variation in the density of the pubescence seems quite independent of the character of the new canes.

It may be noted here that both glabrous and pubescent forms occur wild. The writer has found that while the glabrous forms predominate (as amongst cultivated varieties), a careful search has resulted in the discovery of pubescent forms wherever he has had the opportunity of examining wild raspberries. In at least two districts, in Cumberland and Perthshire, the two forms were found growing together in woods so far from any cultivated raspberries as to leave little doubt that they were indigenous. It is also interesting to find that two varieties sent in for trial (" Lloyd George " and a nameless seedling) both said to have been found growing wild, have pubescent new canes.

Another character often found extremely useful, and constant enough to make the " roguing " of certain varieties comparatively easy, is the contrast or

similarity in colour of the surface of the new cane and the bases of the spines. The spines are practically always stouter at the base and rounded off on to the surface of the cane ; of many varieties this swollen base is very dark-coloured, often nearly black, and is very conspicuous, especially on the green parts of the stem. Where this dark colour is absent, the base of the spine usually becomes reddish or purple at the same time as the stem, and hence is inconspicuous. Of a few varieties (*e.g.*, Profusion and the Scotch Antwerps) the base of the spine becomes coloured rather sooner than the stem ; but these are easily distinguished from those where the base of the spine is always dark-coloured and are included in the " pale-spined " groups. The tip of the spine is often dark-coloured where the base is pale. It should be noted that the spines close to the ground are almost useless for purposes of identification. Nearly all varieties have very spiny canes up to six inches or a foot from the ground, and these spines are usually much more slender than those higher up, and often differently coloured. The spines on the upper part of the cane are alone worth considering.

Before proceeding to give descriptions and notes on varieties, it may be worth while to enumerate all the characters found most generally useful in identifying varieties, and to give a partial key to the more important sorts. It seldom happens that any one character is useful for all varieties, or that the whole group of characters has to be considered for any one variety ; but each character has its use in one connection or another.

New Canes.

Pubescence ; presence or absence of glaucous secretion ; number, length, stoutness, shape, and stiffness of spines on upper part of cane ; colour of base of spine as compared with green parts of stem ; shape, pose (in which is included " curl "), and rugoseness of leaves ; number of leaflets ; colour of leaves, especially of the young growing leaves near the tip ; sometimes the length, thickness and colour of the petiole, and the presence or absence on it of spines.

Fruiting Canes.

Number, size, shape and rarely colour of spines on pedicel and calyx ; size, shape, firmness and colour of fruit ; size of drupelets ; length of calyx lobes ; sometimes pose of inflorescence and length of pedicel.

Some of these characters have to be used with caution. Local conditions greatly affect the number of spines on the new canes ; and still more the development of " leaf curling " ; the latter character is even affected by the season and the amount of shade in which the plants are growing. Many varieties which in June produce almost flat leaves, by August (in a dry season) bear leaves which appear to be almost as much curled as those of Superlative ; and even Superlative varies considerably, and may, in a moist shady place, produce leaves

approaching those of the flat leaved types. The number of leaflets also varies greatly, not only from place to place, but even from cane to cane in the same row ; to those who know varieties well it is some guide, but it is quite useless to others.

While it is impossible as yet to give a complete key for all the varieties mentioned, a separation of the more important sorts into groups by means of the various botanical characters may be of some assistance to those who wish to identify varieties. Further close study may lead to the discovery of characters definite enough to allow of the compilation of a complete key, but this must be left for a later report.

A. New canes densely pubescent.
- B. Base of spine conspicuously darker coloured than stem ; spines short, stout.
  - c. Leaves considerably curled, petiole very short — *Norwich Wonder.* *Steele's Victoria.*
  - cc. Leaves nearly flat, petiole long — *Lloyd George.*
- BB. Base of spine nearly same colour as stem.
  - c. Leaves strongly convex or slightly curled — *Red Cross.*
  - cc. Leaves nearly flat.
    - d. Leaflets large, long, rather narrow, light green — *Park Lane.*
    - dd. Leaflets small, broad, rather dark green — *Red Antwerp B.*

AA. New Canes glabrous or sparsely pubescent.
- B. Base of spine conspicuously darker coloured than stem.
  - c. Leaves much curled, much rugose.
    - d. Canes dark purple (except early in season) — *Pyne's Royal.*
    - dd. Canes green or pale purplish red — *Superlative.*
  - cc. Leaves flattish or slightly curled, often very convex.
    - d. Leaflets long, narrow, light-coloured, fruit very acid — *Semper Fidelis.*
    - dd. Leaflets not as above, fruit mostly sweet. — *Red Antwerp C.* *Red Antwerp D.* *Red Antwerp E.* *Baumforth's S. B.* *Carter's Prolific.* *Fillbasket A.* *Hornet A.* *Laxton's Bountiful.* *Mitchell's Seedling.* *Reader's Perfection.*

BB. Base of spine nearly same colour as stem.	
c. Leaves almost flat.	
d. Canes little glaucous, spines few.	*Bath's Perfection.*
	Canadian Red.
dd. Canes glaucous, spines usually many	*Baumforth's S. A.*
	Hornet B.
cc. Leaves considerably convex	*Devon.*
	Profusion.

Descriptions.

The varieties of which it is considered worth while to give detailed descriptions are some twenty in number. They almost certainly include the great majority of those widely grown for market, with a few which may be of only local importance, or, being of recent introduction, are considered worthy of trial commercially. Of several older varieties, such as true Northumberland Fill-basket and Old Beehive, neither descriptions nor plants have yet been obtained ; these varieties seem largely to have gone out of cultivation, having, no doubt, been generally superseded by better sorts.

The characters included in each description are all those which appear likely to provide any help in identifying the varieties concerned. Those characters found most useful in our conditions (and frequently elsewhere) are printed in italics ; in many cases these alone should serve to identify the variety, but the others given will in each case provide a further guide. In addition is given any available information as to the average strength of growth of each variety (compared with others), and its cropping capabilities as far as known.

Abundance (Laxton's).

This variety as grown here is in all respects identical with No. 8 (Bath's Perfection), which is described below.

1. Antwerp Black. A.

Since this variety is the only one widely grown under the name, it seems likely that it is the original " Black Antwerp " ; it is very commonly planted in Perthshire, usually in mixture with No. 2 (Red Antwerp A). Plantations of the two varieties mixed have been seen in Surrey and Worcestershire ; in two or three of these cases the canes had certainly been obtained from Scotland.

The growth of these two varieties in mixture is, I believe, often intentional ; some growers claim that they do better when mixed than when separated. They usually, however, include also a number of rogues of little or no economic value ; one very common type in particular is much more vigorous than either of the true varieties, but produces only small crops of poor fruit.

FIG. 1.
CANES PUBESCENT.

NORWICH WONDER.
Base of Spine Dark.

RED ANTWERP B.
Base of Spine Pale.

FIG. 2.
CANES GLABROUS.

PYNE'S ROYAL.
Leaves Curled.

BAUMFORTH'S SEEDLING A.
Leaves Flat.

New Canes : numerous, slender, very spreading, in August usually *horizontal near tip*, or even drooping ; colour *dark reddish purple*, at least where exposed, heavily glaucous except near tip, *glabrous*.

Spines *very numerous to tip*, medium length, or rarely less, *very stout, very stiff ;* base of spine nearly same colour as stem.

Leaves considerably curled except early in season ; in dry season often tightly rolled up.

Petiole short or very short except on crowded canes, medium thickness, usually bearing several or many short stiff spines ; colour mainly the same as that of the stem, base of petiole dark purple.

Stipules rather short, almost always curved.

Leaflets rarely more than three, *broad, short,* rather small, abruptly acuminate with rather long point, rather strongly rugose. Colour of older leaves rather dark green, somewhat grayish, *tip leaves reddish.*

Fruiting canes, etc. : *Spines on pedicel and calyx usually many,* large, stout and stiff. Calyx lobes short. *Fruit somewhat conical,* dark red, sweet.

Growth usually weak or very weak, cropping very good for size of canes, would be one of the best if canes were stronger. Fruit usually of good size.

Antwerp Black, B.

This variety, obtained from Norfolk, is very closely similar to No. 7 (Red Antwerp, F.), and is probably identical with it. Growing under widely different conditions, it shows certain points of difference, chiefly in the number and length of the spines, and particularly the spines on the pedicel. But the points of resemblance are so many that it seems hardly worth while to give here a full description, or to regard the name as anything more than a synonym.

2. Antwerp, Red, A.

As noted above, this variety is commonly grown in Perthshire, usually in mixture with No. 1 (Black Antwerp. A). It so closely resembles the latter that it hardly seems necessary to give a full description.

It differs from No. 1, chiefly in its stronger growth, more nearly erect canes, somewhat larger and less curled leaves, and rounder and earlier ripening fruit.

3. Antwerp, Red, B. Fig. 1.

This variety, of which a true strain (free from rogues) was received from a nurseryman, is not widely grown in districts visited up to the time of writing ; a large area of it has been seen in Worcestershire growing in mixture with No. 2 (Red Antwerp, A.) and two or three other forms. It is not at all closely like any other variety so far discovered, and differs from the other five varieties under the same name in having pubescent new canes.

New canes : numerous or very numerous, usually crowded in rows ; rather slender, not very erect, cane often sloping from base. Internodes very short.

Colour mainly green, tinged pale purple, becoming darker later in season ; *densely pubescent.*

Spines *numerous to tip*, slender to medium thickness, *very long*, soft ; *base of spine same colour as stem.*

Leaves *almost flat*, at most slightly convex.

Petiole short, becoming medium length on oldest leaves ; bearing several to many longish spines ; mostly same colour as stem, but base of petiole darker purple.

Stipules very long, half-inch or more, much tapered.

Leaflets usually five, *small, broad*, almost always long acuminate. Surface slightly rugose, often nearly smooth on older leaves ; edges of leaflet often upcurved. Colour moderately dark grayish green, tip leaves little paler, faintly reddish.

Fruiting canes, etc. : Spines on pedicel and calyx several to many, very long, slender ; pedicel rather long. Fruit round or somewhat flattened, drupelets rather large ; rather soft, bright red, very sweet.

Growth usually medium strength or more ; cropping not yet tested. The fruit is inclined to be small, but may be larger on old established canes.

4. Antwerp, Red, C.

This variety was received from Middlesex, with the report that it had been obtained as Red Antwerp direct from a large grower in Perthshire. It is, however, entirely distinct from the variety commonly grown as Red Antwerp in Perthshire ; and no other variety has yet been found that might possibly be identical with it. It has recently been found as a rogue among canes of No. 33 (Profusion).

New canes : Fairly numerous, slender to medium thickness, nearly erect ; internodes rather short. Colour mainly green, with faint trace of red or purple, darker late in season ; rather heavily glaucous, *glabrous.*

Spines numerous to tip, usually more than medium length, sometimes long, stout, stiff, *very much darker coloured than stem*, almost black, *very conspicuous.*

Leaves convex, but little if at all curled except towards the end of a dry season.

Petiole rather long and slender, bearing several to many conspicuous spines ; colour green with trace of purple, base of petiole much more purple.

Stipules rather long, $\frac{3}{8}$-inch or more, rather narrow.

Leaflets often five, except on lowest and uppermost leaves ; long, rather narrow, very similar in appearance to those of No. 10 (Baumforth's Seedling B), until the latter become curled ; rather long acuminate ; considerably rugose ; *strongly upfolded from midrib.* Colour rather light to medium green, slightly greyish, tip leaves not much paler, more yellowish, distinctly reddish.

Fruiting canes, etc.: Spines on pedicel and calyx many, large, stout. Pedicel often short, rarely very long. Fruit roundish oblong or almost round, not conical. Fruit hangs out conspicuously owing to long inflorescence, which is less leafy than many sorts.

Growth appears to be very strong. Cropping not yet tested, reported good.

5. Antwerp, Red, D.

This variety has so far been seen only on one farm, in Norfolk. The grower was unable to give any particulars as to the source from which the canes were obtained. In several respects the variety resembles Bath's Perfection, but it can easily be distinguished by the later ripening of its fruit, and by the darker coloured spines on the new canes.

New canes: moderately numerous, not crowded in row, stout, nearly erect. Colour mainly green, somewhat tinged with red or reddish purple late in season; *very little if at all glaucous* even on lower part; *glabrous*.

Spines few, usually none on upper part of cane, moderately numerous below; fairly stout, medium length, not very stiff, red or purplish red, not very dark, *but much darker than stem*.

Leaves almost flat, especially older leaves, younger slightly convex.

Petiole medium length, stout, bearing few small spines, none on petioles of upper leaves; green, becoming somewhat reddish late in season, redder at base of petiole.

Stipules, long, often ½-inch, rather narrow.

Leaflets seldom five distinct, often four, or three with the terminal deeply lobed; moderately broad, basal pair broader than most varieties, *very little rugose*, older leaves almost smooth. Moderately dark green, tip leaves somewhat paler, sometimes distinctly reddish, but often very little.

Fruiting canes, etc.: Spines on pedicel and calyx rare, usually none, Pedicel short or medium length. Fruit roundish or short-conical, very bright red, drupelets rather large.

Growth appears to be fairly strong. Cropping not yet tested.

6. Antwerp, Red, E.

The grower of this variety, in Norfolk, was uncertain as to the name, but said he received it as "Red Antwerp." It had been suggested to him that it might be "Black Antwerp," but apparently for very little reason except that there are other "Red Antwerps."

The variety is distinct from all others mentioned in this report in its extreme lateness of ripening; grown in the same conditions as No. 15 (Devon), it is fully a week later. It is probably weaker growing than any other "Antwerp" here mentioned, except Nos. 1 and 2 (the Scotch Black and Red Antwerp), and is also distinct in its very flat leaves. The stem is green, becoming purple, glabrous, and the spines are few or very few, dark reddish purple even where the stem is green.

7. Antwerp, Red, F.

This variety was seen growing in Devonshire. A closely similar variety, believed to be identical, has been mentioned above (Black Antwerp, B). Since the grower of the latter had obtained the canes from the same source as those here described, it seems best to retain the name here given. No other name has yet been found for this variety, or indeed for any other of these Red Antwerps, and it is very difficult to guess which of the six types was the first one to bear the name.*

New canes : few, or very few, moderately stout below, slender above, not very erect ; *dark purple* or reddish purple in light, greenish near base and tip ; heavily glaucous ; *glabrous*.

Spines numerous, short, medium thickness, very stiff, *base of spine same colour as stem, very inconspicuous*.

Leaves rather flat early in season, becoming somewhat curled later, especially in a dry season ; very similar in pose to those of No. 10 (Baumforth's Seedling, B.).

Petiole medium length or above, rather slender, bearing few or several small stiff spines ; dark purple, often darker than stem, base of petiole still darker ; much less pubescent and more glaucous than most varieties.

Leaflets rather seldom five distinct, often four with lobed terminal leaflet. Rather long and narrow ; surface moderately or considerably rugose, oldest leaves smoothish ; tips of leaflets much turned inwards, often with a twist sideways. Colour rather light green (plants growing in partial shade), considerably paler near tip ; tip leaves yellowish, only slightly reddish.

Fruiting canes, etc. : Spines on pedicel nearly always several to many. Pedicel rather long, moderately stout. Fruiting growths (*i.e.*, shoots producing inflorescences) very long, similar to Devon, flowering *and fruiting* at every node. Old canes often show some "blindness," several buds fail to break. Fruit distinctly conical, very dark red when fully ripe, with heavy bloom ; hangs out conspicuously. Rather acid even when fully ripe. Slightly later ripening than Devon.

Growth is moderate to strong ; the variety is said to be drought-resistant, and to do better in light soil than heavy.

8. Bath's Perfection. Fig. 9.

This variety is said to be identical with the American variety Marlborough, and presumably belongs to the American species *Rubus strigosus* ; it is certainly

* Since writing the above I have received a note from Mr. Pyne, of Topsham, the well-known raiser of new raspberries, saying that an acquaintance of his always called this variety "Barnet." This name appears frequently in the horticultural literature of last century : I much hope that we have now discovered the variety to which it belongs.

identical with " Laxton's Abundance," which we have in our collection ; and I believe it is also known by one or two other names. The variety is, unfortunately, one of the most susceptible of all to the " die-back " disease, and may have to be given up on that account ; the disease appears, however, to have done less damage in 1922 than in the previous two years, and may be becoming less serious.

New canes : Numerous or very numerous, but usually not closely crowded in the row, very stout, stiff, *very erect* ; internodes short ; colour greenish, soon becoming *very bright red or reddish purple. Not glaucous ; glabrous.*

Spines *few or very few*, often none, medium length, rather slender, soft, base of spine nearly same colour as stem, or slightly redder.

Leaves rather flat, sometimes more or less curled late in season.

Petiole rather short or medium length, stout, nearly same colour as stem, noticeably darker red at base of petiole ; usually bearing very few small spines or none.

Leaflets rather narrow to medium width, gradually acuminate to a long fine point ; surface less rugose than many varieties, rather distinctly shiny ; colour *dark bluish green*, strikingly different from most varieties ; *tip leaves very reddish.*

Fruiting canes, etc. : Spines on pedicel and calyx rare, usually none. Inflorescence very leafy to tip, leaves hiding fruit ; fruit round or somewhat flattened, very bright red, very variable in flavour.

Growth is usually strong (here rather weak) ; cropping, where not reduced by " die-back," very heavy.

9. Baumforth's Seedling, A. (Probably the original Baumforth.) Fig. 2.

Of the three varieties received here under this name, this one most closely resembles early descriptions of " Baumforth's Seedling." It seems to be very seldom grown for market, the name having been transferred to No. 10 (Baumforth's Seedling, B.), which is now one of the most widely grown of all varieties. The old Baumforth's, however, is a much superior variety, at least for jam making ; and although slightly acid and rather soft for marketing in chips, is not to be despised for dessert purposes.

New canes : moderately numerous, sometimes very many ; fairly stout, rather spreading. Colour green, becoming rather light purplish red where exposed ; moderately glaucous, *glabrous.*

Spines numerous to tip, long, rather stout, stiff ; *base of spine same colour as stem*, tip usually darker,

Leaves flattish, often very flat, at most only convex, not curled.

Petiole medium length or more, rather stout, bearing several to many rather stout stiff spines ; practically same colour as stem, base of petiole considerably darker. Channel of petiole more distinct than in most varieties

Leaflets usually less than five, often three, *short, broad,* acute or very short acuminate ; surface moderately rugose, oldest leaves often nearly smooth ; margin nearly always wavy. Colour of older leaves dark, rather dull bluish green ; tip leaves considerably paler, usually yellowish, only slightly reddish.

Fruiting canes, etc. : Spines on pedicel and calyx many or very many, large ; pedicel rather long. *Fruit round,* or somewhat flattened, soft and juicy, rather acid ; often very large.

Growth medium to strong ; cropping not yet tested here, heavy in some places.

10. Baumforth's Seedling, B. (Most commonly grown as Baumforth.) Figs. 4 and 8.

This variety was received here under the name of " Fastolf " ; but since there is a doubt whether it has any right to that name, and since it is very widely grown as " Baumforth's Seedling " and seldom under any other name, it has been thought best to accept the grower's name tentatively. The variety is almost, if not quite, the most widely planted of all ; while Bath's Perfection probably somewhat exceeds it in total area, no other can yet come within a long distance of these two. And this variety is undoubtedly the most cosmopolitan of all ; it is widely planted in Perthshire where Bath's Perfection is found almost useless, as well as in every other district so far visited.

New canes : very many, crowded in the row, and very much " spawn " often many feet away ; not very erect, often becoming rather spreading. Colour mainly green, except in full light, where it is pink or purplish. Moderately glaucous, *glabrous. Internodes of crowded canes very long.*

Spines usually few, sometimes none ; short, rather stout, often very small, not very stiff ; *base of spine dark purple,* even where stem is green, *very conspicuous.*

Leaves merely convex early in season, usually considerably curled later, especially towards the end of a dry season.

Petiole rather long (very long on crowded canes), rather slender ; *bearing very few spines,* usually none, colour nearly the same as stem, base of petiole more purplish.

Stipules long, usually more or less curved.

Leaflets often five distinct, medium width or less, often rather narrow. Surface considerably and rather finely rugose, ridges narrow and very equal in width. Colour rather dark greyish green, tip leaves paler, but not yellowish, often with faint reddish tinge.

Fruiting canes, etc. : Spines on pedicel and calyx few or none, where present, rather large. Pedicel usually long or very long. *Fruit distinctly conical, very firm, sweet,* drupelets rather small.

Growth nearly always strong, cropping very heavy. Succeeds better than most varieties in poor soil.

FIG. 3.
CANES GLABROUS.

SEMPER FIDELIS.
Base of Spine Dark.

DEVON.
Base of Spine Pale.

C. B.

FIG. 4.
TWO VARIETIES GROWN AS "BAUMFORTH'S SEEDLING."

FIG. 5.
SUPERLATIVE.

11. Baumforth's Seedling, C. Fig. 4.

This variety was received under this name from only one source. It is certainly not widely grown under any name ; it has been found as a rogue among plants of No. 20 (Hornet A), and is now known to be sometimes grown as " Hornet " (see " A Note on the Impurity of Raspberry Stocks " in this issue). The original stock as received contained a small proportion of canes of No. 20 (Hornet A).

New canes : numerous, often closely crowded in the row, rather slender, nearly erect early in season, later growth nearly horizontal. Colour green, becoming strongly tinged with *bluish purple* where exposed. Heavily glaucous ; *glabrous* or very slightly pubescent.

Spines usually several to tip, occasionally few or none ; medium length or longer, rather stout. Moderately stiff, *base of spine same colour as stem.*

Leaves considerably convex or moderately curled, much curled towards the end of a dry season.

Petiole medium length or above, rather slender, usually bearing few very small spines ; almost same colour as stem, channel of petiole deeper than in most varieties.

Stipules long or very long, often half an inch.

Leaflets often five, medium size, medium width (or wider than most varieties having five leaflets) ; considerably rugose and rather more coarsely and irregularly so than most varieties. *Colour distinctly yellowish green,* rather light ; tip leaves paler and very yellowish, hardly any red tinge.

Fruiting canes, etc. : Spines on pedicel and calyx few or none ; calyx lobes very long ; *fruit round, very soft,* rather pale red, sometimes pinkish.

Strength of growth here not above medium, cropping also medium.

12. Beehive, Improved.

The canes received under this name from a Cornish grower appear to consist of two types very closely similar. Both have inconspicuous spines, the same colour as the stem ; one closely resembles No. 19 (Helston), differing from it chiefly in the colour of its spines : the other has much broader and somewhat more rugose leaflets. I have not yet seen any plants of the old " Beehive," and am unable to say whether either of these at all resembles it.

13. Canadian Red.

This variety, grown in one or two districts in Cambridgeshire, closely resembles No. 8 (Bath's Perfection), but is distinguished by its taller growth and slightly smaller fruit, which is somewhat lighter red in colour. It seems probable that it will prove to be identical with one of the varieties grown in Canada and the United States ; I am not well enough acquainted with these varieties to be able to suggest its correct name.

14. Carter's Prolific.

It has not yet been possible to obtain a full description of this variety. As the writer has seen it in various places, the canes are somewhat weak, erect below, nearly horizontal at tip (late in season); very short jointed, very glaucous, glabrous. The spines are dark and very conspicuous. The leaflets are small and nearly round, pale green in colour. The fruit is almost round, small wherever seen up to the present; and the cropping very heavy.

15. Devon. Fig. 3.

This variety seems to be nearly always correctly named and usually free from rogues. It does best in a wet season or on a soil fairly retentive of moisture; it appears to be less drought resistant than most varieties.

New Canes: numerous in row; fairly stout, not stiff, nearly erect. Colour in later part of season a rather bright purple; green in dense shade. Heavily glaucous; *glabrous*.

Spines usually numerous to tip, short, stout, rather stiff, *base of spine same colour as stem.*

Leaves often considerably curled, seldom flattish; upper half of terminal leaflet often twisted sideways.

Petiole usually rather short, moderately stout, usually bearing several small stout spines. Colour like stem, becoming darker. Channel of petiole deeper than in most varieties.

Leaflets large and *very broad, margin very wavy*; usually rather long-acuminate. Serration very coarse. Surface rather strongly and coarsely rugose even on older leaves. Colour rather dark greyish green; tip leaves somewhat paler, but not yellowish, often somewhat reddish.

Fruiting canes, etc.: Spines on pedicel few or several, on calyx usually none. Calyx lobes of fruit much reflexed, more than most varieties. Fruit oblong conical, often roundish late in season, moderately firm (soft in some soils) *rather late ripening;* sometimes difficult to pick "plugged," at least when plants are young.

Growth strong, sometimes very strong (seems to be weak in some soils). Cropping in a moist soil usually very heavy, and fruit often very large. In dry soils much of the blossom fails to produce fruit.

16. Fastolf A.

It has not yet been possible to obtain a full description of this variety. It closely resembles No. 20, Hornet, A, but it is certainly distinct. The foliage is somewhat less rugose than that of Hornet, and the tip leaves less reddish; the fruit is more uniformly round and scarcely as large as that of Hornet. In the

few places where this variety has been seen it appears to produce very few rogues, while Hornet in the same soil is very soon full of them.

Fastolf, B., see No. 10 (Baumforth's Seedling, B).

17. Fillbasket, A.

This variety has been seen growing in mass only in Norfolk. It seems probable, however, that it is grown elsewhere ; a very similar form, probably identical, has been found as a rogue among two lots of Baumforth's Seedling, B. (No. 10), and one lot of Mitchell's Seedling (not true) obtained from Perthshire.

The variety is distinguished by its very slender canes, which are mainly green, moderately glaucous, and glabrous. The spines are moderately numerous (until rubbed off the upper part of the cane—the weak canes are much blown about by the wind), medium thickness, and reddish purple at the base, conspicuous on the green parts of the stem. The leaves are rather similar to those of No. 20 (Hornet, A.) ; the leaflets, nearly always three in number, are large and rather broad, considerably curled, usually with a twist sideways ; they are less rugose than those of most varieties with so much curling.

The fruit is roundish oval, seldom conical, firm and rather dry, neither sweet nor very acid, pleasantly flavoured.

Fillbasket, B.

One or two growers in Kent have a variety under this name which closely resembles Norwich Wonder ; probably the same variety is grown in Perthshire as " Laxton's Fillbasket," or " Laxton." No points of distinction from Norwich Wonder have yet been found.

See also 22 (Kirriemuir Fillbasket), and 26 (Northumberland Fillbasket). Probably other varieties besides these are grown as " Fillbasket."

18. Goliath.

This variety has occasionally been planted for market purposes, but seems in most places to be of little value. It is characterised by very strong, erect canes, which throw up " spawn " at a very great distance from the row (sometimes twenty or twenty-five feet) ; the canes are glabrous, and the spines few or very few, and little darker than the stem ; the leaves are flat and usually show no sign of curling. Fruit small and cropping usually poor.

19. Helston.

A variety received from a Cornish Grower, said to be commonly grown for market in the Tamar Valley. It is characterised by flattish leaves and somewhat narrow, pointed leaflets ; the spines are darker coloured than the (glabrous) stem ; the fruit is nearly round, medium in size, and decidedly acid in flavour.

20. HORNET, A. Fig. 7.

This is probably the only variety commonly grown as "Hornet," though one occasionally finds other well-known varieties wrongly called "Hornet," in addition of No. 21 (Hornet B.) and No. 11 (Baumforth's Seedling, C.). Growers often complain that a plantation of Hornet soon become very full of rogues, I have seen many such plantations where the rogues far outnumbered the true plants. The rogues are certainly not all of one type, though most of them are practically worthless; whether their appearance is to be attributed entirely to the growth of seedlings, or partly to "bud-sporting" from the roots, I am unable to say. I have seen a Plantation of a type called "Improved Hornet" in Cambridgeshire, very similar to the common type, where very few, if any, rogues had appeared in the five or six years since it was planted.

New Canes: Numerous, sometimes very numerous, moderately stout, nearly erect. Colour soon becoming *rather dark purple* where exposed, greenish in shade; moderately glaucous; *glabrous*.

Spines few on upper part of stem, short, rather slender, soft; characteristic colour, rather *light purplish red* where stem is green, becoming dark later; not very conspicuous, but darker than stem.

Leaves somewhat flattish early in season, becoming very convex or slightly curled later, especially in a dry seasom.

Petiole rather short to medium length, moderately stout, bearing few small spines, often none on upper leaves. Nearly same colour as stem.

Stipules rather short.

Leaflets usually three, sometimes five, broad, often rather short, *considerably and coarsely rugose*, more so than most varieties whose leaves are no more curled. Colour of old leaves dark greyish green, youngest leaves bright yellowish green, often distinctly reddish when half expanded.

Fruiting canes, etc.: Spines on pedicel and calyx few, small, usually none; calyx lobes long, noticeable in flower bud. Inflorescence large and loose, pedicel very long. Fruits large, almost round or slightly short-conical; drupelets large; sweet.

Growth usually medium in strength. Cropping (apart from rogues) very heavy.

21. HORNET, B.

This variety was sent to us as Hornet, but proved to be entirely distinct from No. 20. It is so closely like No. 9 (Baumforth's Seedling, A.), that it will hardly be necessary to give a full description. It is, however, difficult to believe that the two are identical. Hornet B. is distinctly weaker growing, makes more crowded canes, and bears fruit little more than half the size of that of No. 9. Until 1921, the original plants (since torn out) produced hardly any fruit worth

picking; in 1921, however, the fruit was much improved in both size and quantity. If the improvement is maintained in the newly-planted row, the variety will be much more closely like No. 9.

22. Kirriemuir Fillbasket.

A variety obtained from Perthshire with the report that it "degenerates" rapidly to a form of much less value. The true type is said to be the largest fruited and the heaviest yielder of all varieties known in Perthshire; the few plants of it that I saw there fully bear out this reputation.

The variety is distinguished by dull reddish purple canes, heavily glaucous, and glabrous; the spines are few or almost absent; when present they are short, rather stout, and slightly darker coloured than the stem. The leaves are flattish, and the leaflets rather broad and strongly rugose for so flat a leaf. The pedicel is almost or quite free from spines. The fruit is very round, similar to No. 20 (Hornet, A), but much larger (in Perthshire) and brighter red; the receptacle is enormously swollen and nearly round.

The "degenerate" form, called "Common Fillbasket," differs very much from the true type; the canes are much less purple and mainly green; the spines much darker, very dark purple and conspicuous; the leaflets are much longer and narrower, much more acuminate, and much less rugose. The fruit is much smaller and the cropping said to be heavy, but far short of the true type.

23. Laxton's Bountiful.

This new variety is well worth testing, except perhaps in the less fertile Raspberry soils. But it appears to be rather partial to some soils; in some places the growth is too weak to allow of heavy cropping, and this although other varieties grow strongly. But wherever Bountiful will make enough cane it should prove to be an acquisition.

New Canes: numerous, moderately stout, nearly erect. Colour becoming purplish red, pale, except in full light, green in deep shade. Considerably glaucous, *glabrous*.

Spines generally numerous to tip, short, moderately stout, rather stiff, *dark bluish purple where stem is green*, conspicuous.

Leaves flattish on strong growing canes, with characteristic pose, somewhat similar in this respect to Mitchell's Seedling.

Petiole rather short, moderately stout, bearing few to several small spines; becoming purplish red rather sooner than stem; base of petiole distinctly darker purplish red.

Stipules medium length, usually curved.

Leaflets on some plants often five, generally three or four, with an occasional five. Rather large, medium width or slightly wider, mostly gradually long-

acuminate, considerably and rather coarsely rugose ; colour on vigorous plants light green, somewhat greyish ; tip leaves somewhat paler, whitish, not yellowish, seldom any red tinge.

Fruiting Canes, etc. : Spines on pedicel numerous, rather long, on calyx fewer and shorter. Fruit usually somewhat conical, rounded at apex.

Growth strong in places, often rather weak. Cropping not yet tested ; should be heavy where growth is strong. Fruit here good size, not exceptionally large.

24. Lloyd George.

This variety is one of the most promising of recent introductions. It is reputed to be a " perpetual " fruiting variety, but seems unreliable here in that respect ; not much more than one-third of the new canes have so far flowered in the autumn. But as a summer fruiting variety it should prove to be very valuable.

The variety is distinguished by stout canes, nearly erect, mainly green in colour and densely pubescent. The spines are very numerous, small, rather stout, and very dark coloured, very conspicuous on the green stems. The leaves are very flat. The fruit is very long in shape, more oblong than conical, rounded at the end (the later fruits are sometimes nearly round) ; large, and of good sweet flavour. The receptacle is often enormously long, sometimes as much as an inch.

25. Mitchell's Seedling.

This variety, largely grown round Blairgowrie, has not yet been met with in England, except in the possible case of some recently planted canes in Worcestershire, and possibly as a rogue among other varieties. Some of the Perthshire growers, however, think it is not a local variety, but is known elsewhere under another name ; some, I believe, call it " Semper Fidelis." It is quite distinct from all the other varieties mentioned here.

New Canes : Moderately numerous, nearly erect, stout or very stout. Colour mainly green, becoming rather bright reddish purple in strongest light ; moderately glaucous, *glabrous*.

Spines moderately numerous, fewer near tip, short, fairly stout, stiff ; *dark bluish purple* where stem is green, very conspicuous.

Leaves flattish, becoming *evenly convex*, not appreciably curled. Pose of leaf is very characteristic, especially in the uniform curving down of the edge of the leaflet.

Petiole rather long, medium thickness, usually bearing several minute spines, green, except in full light.

Stipules rather long, usually curved and divergent.

Leaflets often five (in some soils usually three), rather large, often long, generally acute, sometimes slightly acuminate; rather distinctly rugose. Colour rather light yellowish green; tip leaves somewhat reddish brown on tops of ridges.

Fruiting Canes, etc.: Spines on pedicel and calyx usually few or none. Pedicel long, slender, very drooping. Fruit roundish or very slightly oblong or conical.

Growth usually strong; canes start well immediately after planting. Cropping not tested here, in Perthshire very heavy.

26. Northumberland Fillbasket.

A variety received under this name was found quite worthless here. The fruit was too small to be worth picking, although the cropping was fair. I have several times been told that a good variety is grown under this name, but I have not yet seen it. Possibly it is the correct name for No. 17.

27. North Ward.

The Cornish grower who sent us Nos. 12 and 19 also sent this with the note that the name was local, and was thought by growers in his district to have been applied to a variety grown elsewhere under another name.

Most of the plants appear to be identical with No. 19 (Helston), but a few are quite distinct, and cannot be certainly identified with any other variety I have seen. These few are characterised by rather strong stout glabrous canes, not very erect, with many rather long stout spines not darker coloured than the stem. The leaves are unique in their pose; the terminal leaflet especially is much curved or almost folded downwards at a short distance from the mid-rib, the leaflet often appearing to be very long and narrowly triangular in shape. The few fruits so far seen have been large and similar in shape to Superlative, irregularly conical. The cropping promises to be fairly heavy.

28. Norwich Wonder.

This old variety is very distinct in the appearance of its foliage, and is consequently easy to keep free from rogues during the summer. It frequently occurs in almost true strains; and one rarely finds other varieties called Norwich Wonder. Some growers in Kent, as noted above, have a variety they call "Fillbasket," which appears to be identical with Norwich Wonder; and a variety called in Perthshire "Laxton's Fillbasket," or "Laxton" is probably the same. I was told at Blairgowrie that there are other varieties known by this name ("Laxton"), but I did not manage to find any.

New Canes: *Usually few*, seldom numerous, not crowded in row; rather stout, almost erect. Colour mainly green, with slight purplish tinge late in season; glaucous secretion not noticeable; *densely pubescent*.

Spines usually numerous to tip, medium length, usually rather stout and stiff, *base of spine much darker coloured than stem*, conspicuous.

Leaves considerably curled (flattish in a wet season), with characteristic pose, each leaflet nearly flat across, but strongly curved down near middle of length, giving whole leaf a squarish appearance as seen from above.

Petiole *very short* (rachis also), moderately stout ; its shortness makes the canes appear more leafy than those of most varieties ; usually bearing few to several small stout spines ; colour same as stem, base of petiole not much more purple.

Stipules rather short, broader than those of most varieties.

Leaflets seldom five distinct, rather large, short, *very broad*, abruptly short-acuminate. Serration coarse ; surface *very strongly* and coarsely *rugose*. Colour bright green, rather dark, somewhat bluish but not greyish, tip very much paler, usually pale yellow green, sometimes faintly reddish.

Fruiting Canes, etc. : Spines on pedicel usually many, large and stout, on calyx several to many, smaller. Pedicel short, stout. Fruit mostly somewhat conical or roundish oval, drupelets rather large ; flavour sweet, very good ; early ripening.

Growth often weak, rarely above medium strength. Cropping heavy for size of canes.

29. "Paradise Berry."

A variety received from Stavanger, Norway, with the report that in Norway it produces larger fruit than Pyne's Royal. As grown here up to the present the fruit is large but not exceptional in size. The variety produces new canes slightly resembling No. 8 (Bath's Perfection), and still more No. 32 (Prior's Prolific) in general appearance ; but it is quite distinct from these in its densely pubescent canes. The spines are numerous, long, moderately stout, and are the same colour as the stem, and inconspicuous. The pedicels are spiny and the fruit has so far been usually quite round, rarely slightly conical.

30. Park Lane.

A variety said to produce the best flavoured fruit of all varieties in cultivation. The fruit as grown here is certainly very fine in flavour, but the variety unfortunately has faults which rule it out for market growers, at least in our conditions. The canes appear to have developed the habit of "going blind" during the winter ; a large proportion of the buds fail to break and the crop is consequently very light. In some places it is said to crop well, and the fruit is often described as large ; here it is no more than medium in size.

The variety is very distinct in its densely pubescent canes, its great number of very long slender pale coloured spines, and its flat narrow leaflets which are

distinctly light green, almost as light as those of Semper Fidelis. The spines on pedicel and calyx are also very numerous. The fruit is almost round, sometimes slightly flattened.

31. Penwill's Champion.

A variety believed to be grown in the south-west, sent to us from Norfolk, by a grower who obtained it from Devonshire. It has not been yet possible to make a description, but two points may help to distinguish the variety—its characteristic reddish colouring round the edges of the older leaves in summer or early autumn (probably absent in some soils) and the firmness and lack of juice of the roundish or slightly oval fruit. The spines on the new canes are very dark coloured and conspicuous.

32. Prior's Prolific.

A new variety sent in for testing. The growth and appearance of the new canes are very similar to those of No. 8 (Bath's Perfection), but this variety is decidedly more vigorous and the canes are slightly less erect. The fruit as grown here is larger than Bath's Perfection but otherwise similar. Cropping not yet sufficiently tested.

33. Profusion (Bunyard's).

The new canes of this variety appear to be extremely variable in several characters, particularly the shape and pose of the leaflets; it has been at times difficult to deside whether an apparently distinct plant was actually a rogue or not. It has been found, however, that the rogues occurring in the variety are usually distinct from the true form in having darker spines. The pale spines of the true form will distinguish it from No. 20 (Hornet, A.) where other characters fail.

New Canes: Often rather few, here moderately numerous, rather slender, fairly stiff (though often much bent down in second year by weight of fruit), almost erect except near tip. Colour becoming rather bright reddish purple; moderately glaucous; *glabrous*.

Spines usually numerous to tip, medium length, rather stout, soft; *base of spine same colour as stem*.

Leaves becoming very convex or slightly curled, much like those of No. 20 (Hornet, A.), in general appearance, but more often with five leaflets.

Petiole short, stout, bearing few to several stout spines, often more purplish than stem, base of petiole always dark coloured.

Leaflets short, rather broad, often long acuminate. Surface considerably and finely rugose; margin often slightly wavy. Colour dark greyish-green, tip leaves only slightly paler, grey or whitish, not noticeably yellowish, little red

tinge. The leaflets are slower than those of most varieties in expanding to their full width ; those of the tip leaves appear very narrow.

Fruiting Canes, etc. : Spines on pedicel and calyx several to many, rather large ; calyx lobes long. Fruit usually somewhat oblong, sometimes practically round, seldom conical ; drupelets large and deep, flesh thick and heavy, very soft.

Growth usually rather weak to medium, sometimes fairly strong. Cropping here good, sometimes very heavy. Fruit often very large.

34. Pyne's Royal.

In our soil this variety is the most promising of recent introductions ; although there are places where it does not succeed, it is worth a trial, unless known to fail. Of the ten varieties whose crop has been recorded for four years, this has done the best (see Table on p. 12) ; but it was slower in reaching its heaviest yield than several other varieties. Though in many respects much like Devon, it seems distinctly more drought resistant than that variety.

New Canes : Few for two or three years after planting, then moderate number ; fairly stout and stiff, nearly erect (in the second year the weight of fruit bends the canes much down, in spite of their stiffness). *Colour becoming dark purple or reddish purple ;* heavily glaucous, *glabrous.*

Spines few, sometimes almost absent on upper part of cane, rather short, rather stout, fairly soft, *base of spine dark purple where stem is green,* conspicuous.

Leaves *very much curled,* usually nearly as much so as Superlative, but with more twist sideways.

Petiole medium length and thickness, bearing few small spines, often none on upper leaves ; nearly same colour as stem, base of petiole darker purple.

Leaflets medium size, rather narrow to medium width, long-acuminate. Surface *very strongly and finely rugose ;* tip of terminal leaflet usually turns inwards and often upwards, sometimes nearly touching petiole. Colour *dark rather dull green,* tip leaves slightly paler, not much yellowish, *often very reddish.*

Flowering Canes, etc. : Spines on pedicel and calyx of terminal flowers of inflorescence nearly always several to many, few or none on others. Pedicel rather stout, medium length. Fruit distinctly conical or short-conical, sometimes with slight constriction at middle ; drupelets large.

Growth here fairly strong, in places weak ; cropping here very heavy ; fruit the largest of all grown here for more than one year.

35. Reader's Perfection.

A variety of recent introduction similar in several respects to No. 10. (Baumforth's Seedling, B.), but somewhat more robust in growth, and with slightly larger fruit, not quite so firm when ripe. Worth a trial, especially in the less fertile Raspberry soils.

New Canes : Numerous, rather crowded in rows, moderately stout, nearly erect, but much sloping near the tip ; internodes long. Colour green in shade, distinctly purplish in light. Moderately glaucous ; *glabrous*.

Spines usually moderately numerous to tip, sometimes few ; medium length and thickness, soft and brittle ; *base of spine much darker than stem*, dark bluish purple, very conspicuous.

Leaves flattish or moderately convex, becoming somewhat curled late in season.

Petiole about medium length (long on crowded canes), rather slender, nearly always bearing several or many short rather stout spines ; colour same as stem, base of petiole distinctly darker purple.

Stipules rather long, often $\frac{3}{8}$-in. or more, rather broad.

Leaflets rather large, slightly broader than those of No. 10 (Baumforth's Seedling, B.), otherwise very similar. Surface moderately rugose, older leaves nearly smooth. Leaflets often somewhat upfolded from midrib. Colour distinct lightish grey green, tip leaves somewhat paler, grey or whitish rather than yellowish.

Fruiting Canes, etc. : Spines on pedicel few, rather long, slender ; on calyx usually none. Pedicel long, very drooping. Fruit generally distinctly conical, rather dull purplish red, rather soft and juicy ; drupelets rather small.

Growth usually strong or very strong ; cropping not yet tested here, probably heavy. Fruit often large, though not exceptional in size.

36. Red Cross.

A variety of recent introduction which appears to be more drought-resistant than most sorts. Even in the dry summer of 1921 it produced fairly strong new canes, and the rather weak canes of the previous year (freshly planted) fruited very heavily. Well worth a trial in poor and dry soils.

New Canes : Few on young plants, moderate or numerous when older ; moderately stout, nearly erect early in season, bending over at tip later. Internodes long. Colour *mainly green*, slight tinge of purple in light ; *pubescent*.

Spines moderately numerous to tip, medium length or more, rather stout, stiff, *base of spine same colour as stem*, inconspicuous.

Leaves flattish or convex, usually becoming moderately curled late in season.

Petiole medium length or more, stout, usually bearing few small stiff spines. Green with slight purple tinge, base of petiole slightly more purple.

Leaflets large, *very broad*, acute or slightly acuminate ; surface slightly to moderately rugose (considerably on young leaves). Colour light greyish green, not yellowish, tip leaves somewhat paler, slightly reddish.

Fruiting Canes, etc. : Spines on pedicel several or many, large and prominent ; on calyx few or none. Pedicel rather short in flower, becoming long or

very long. Fruit variable in shape, mostly rather long conical with rounded apex, sometimes almost round ; very uniform in size ; dark rather dull red, rather soft and juicy.

Growth strong, sometimes very strong. Cropping not yet tested, but very promising. Fruit often large, seldom exceptional.

37. Red Magnum Bonum.

This variety, seldom grown for market, has been seen in several collections of varieties, and was found as a rogue in No. 33 (Profusion). It is characterised by strong, erect, nearly glabrous green canes, with numerous very dark coloured stout spines, and almost flat leaves ; the tip leaves are very distinctly reddish (at least late in the season). The fruit is of good size and roundish or somewhat oblong conical ; the drupelets are very large.

38. Semper Fidelis.

There is probably less confusion in the naming of this variety than in that of any other old sort. It is fairly distinct in several characteristics, particularly its acid fruit ; the only old variety with which it is likely to be confused is No. 10 (Baumforth's Seedling, B.), and here the acidity of the fruit is an almost certain distinction. The variety is particularly well liked by jam-makers on account of the good colour and clearness of the jam made from it.

New Canes : Numerous, somewhat crowded in row, slender to medium thickness, erect or nearly so except near tip ; internodes long or very long. Colour mainly green, with purplish tinge in places. Distinctly glaucous, *glabrous*, or sparsely pubescent.

Spines usually numerous to tip, sometimes few, medium length, stout, not very stiff ; *base of spine dark purple, almost black*, very conspicuous.

Leaves flattish early in season, becoming considerably convex or often somewhat curled later.

Petiole rather long, slender to medium thickness ; usually bearing many short stout conspicuous spines. Colour green with slight purple tinge in light, base of petiole darker purple. Channel of petiole rather conspicuous.

Leaflets usually five, except near base and tip of cane, *very narrow*, medium length, moderately acuminate ; surface moderately rugose, older leaves nearly smooth. Colour usually *light green*, rather greyish, tip leaves considerably paler, not much yellowish, no red tinge.

Fruiting Canes, etc. : Spines on pedicel several to many, rather long and stout ; on calyx fewer and smaller. Pedicel medium length to long. Fruit oval or somewhat conical, often nearly round, rather dull dark purplish red, *very acid*, rather late ripening.

Growth usually above medium strength, often very strong, cropping heavy. Fruit of medium size, rarely very large.

Fig. 6.
Profusion.

Fig. 7.
Hornet A.

Fig. 8.
Baumforth's Seedling B.

Fig. 9.
Bath's Perfection.

39. Steele's Victoria.

It has not yet been possible to find any certain distinction between this variety and No. 28 (Norwich Wonder). It appears, however, to be distinct; for in our soil it usually transplants only with difficulty and the loss of many canes, while Norwich Wonder transplants very easily and starts well. The rogues occurring in this variety are quite distinct from those usually seen in Norwich Wonder. The fruit is possibly a little later ripening, and less conical, more nearly round in shape, than that of Norwich Wonder.

40. Superlative.

This once valuable variety appears to have deteriorated and to be now in most soils scarcely worth planting. In our soil the canes are always too weak to allow of heavy cropping; what cane there is, however, produces an abundant crop. Where the growth is strong enough, the variety is still one of the best.

New Canes: Very few, moderately stout, erect, internodes short. Colour green, sometimes with tinge of purple; rather heavily glaucous; *glabrous*.

Spines few or none except near ground; medium length and thickness, moderately stiff; base of spine distinctly *darker coloured than stem*, conspicuous where stem is green.

Leaves *very much curled*, more so than those of any other variety grown here; (in moist soil and partial shade sometimes flattish).

Petiole short, moderately stout, bearing few minute spines, or none. Colour green, sometimes purplish late in season; base of petiole little more purple.

Stipules short, narrow.

Leaflets short, broad, usually short acuminate. Surface *very much rugose*, rather more finely so than most varieties. Colour *dark green*, more bluish than greyish; tip leaves much paler, whitish, not much yellowish, little red tinge.

Fruiting Canes, etc.: Spines on pedicel usually several to many, rather large; on calyx rare, usually none. Pedicel stout and stiff, medium length. *Whole inflorescence held stiffly up*, pedicels erect in flower, somewhat drooping when fruit is full grown. Fruit variable in shape, often somewhat conical with a slight constriction near middle; more usually roundish oblong. Rather dark red, sweet.

Growth usually weak, here very weak, in some soils fairly strong. Cropping for size of canes very heavy. Fruit often very large.

NOTES ON THE CHARACTERS OF APPLE TREE SHOOTS.

By D. BOYES, B.A., Dip. Hort. (Cantab.)

The following paper deals with the morphology and behaviour of the various types of shoots produced by an Apple tree and is intended to serve as an introduction to a more detailed consideration of the questions of habit of growth and reaction to pruning.

So far, very little material dealing with the subject has appeared in English; in fact, there are not even English names for certain shoots, though in France horticulturists carefully distinguish between the different types and have names for them. It seems desirable, therefore, before attempting any description of habit of growth or of the effects of pruning, to classify as far as possible the different productions usually found on apple trees.

With regard to the question of nomenclature, the writer has decided to adopt the names used in France. An alternative course is that followed by Quinn in his well-known book on pruning. Quinn uses compound terms such as " fruit-shoot " or " leaf-twig." There is, however, an element of vagueness in the words " shoot " and " twig " which is not present in the names " brindille " or " dard," and for this reason the writer prefers the French terminology.

Some difference of opinion exists among French experts concerning nomenclature, and the system used here is, where possible, that of Passy.

Productions on wood of the current year. An axillary wood-bud situated upon a main shoot usually remains dormant during the season of its formation. In certain circumstances, however, it may develop into a fruit-bud. This development often takes place on maidens, and on trees of most commercial varieties which are in process of formation and have plenty of vigour. Weak leading shoots and spindly maidens have not been observed by the present writer to carry axillary fruit buds during their first year.

Where there is an excess of vigour, as in the case of top-grafted trees, trees which have been pruned back into old wood, and on very strong maidens, a wood-bud may break into growth in the season of its formation. Such growths are, of course, rarely fertile, though occasionally, on vigorous maidens of certain varieties they will be found bearing a terminal fruit-bud in their first season. These shoots possess several points of interest. They are in some respects morphologically dissimilar from shoots produced on last year's wood, and, in addition, have the so-called " stipulary eyes " well-developed. Since these stipulary eyes are of importance in some forms of pruning, it may be

worth while to devote a few words to them and to the shoots which exhibit them so plainly.

Wood-buds which remain dormant are usually small and closely adpressed to the parent shoot. Some buds, however, will be noticed in winter to have taken up a position more or less approaching the horizontal ; and above such a bud, on the main stem, will usually be seen a slight swelling. At this stage the two stipulary eyes can as a rule be detected in the position shown in Figure 10. This change in the position of the bud may be the limit of the season's development. On vigorous leading shoots of most varieties of the Pear buds will usually be found in all stages, from those closely adpressed to those almost horizontal.

A development of the bud greater than that described results, of course, in the production of a shoot. These shoots may be of three kinds : (*a*) a short stub, somewhere about an inch in length, feeble, and often with woolly bark; (*b*) a shoot, up to four inches long, with smooth bark, longer internodes, prominent stipulary eyes, and, in the case of young seedling Pears and Plums, often terminated by a thorn instead of a bud; (*c*) a shoot similar to the preceding, but longer and usually with a distinct drooping tendency. At the base of each of these two last varieties is to be seen a "basal swelling," this feature being very pronounced in the Pear (Fig. 10).

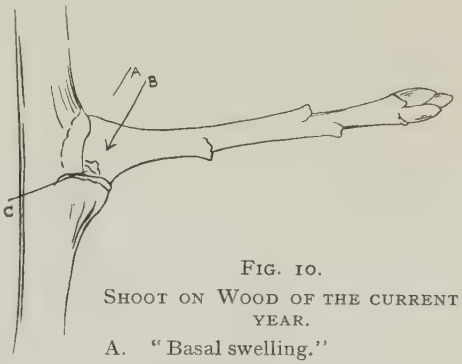

Fig. 10.
Shoot on Wood of the current year.
A. "Basal swelling."
B. Stipulary eye.
C. Scar of small leaf below stipulary eye.

Often a small scar can be seem immediately below the stipulary eye. This scar marks the position of a small leaf which varies in shape and size according to the variety of Apple. It will be seen, therefore, that the " stipulary eyes " have nothing to do with the stipules, since they are in the axils of small leaves (which may themselves have stipules) at the base of the young shoot.

A careful distinction must be made between the shoots just described, which arise naturally from wood of the current year, and shoots which arise as a result of summer pruning from buds that would otherwise have remained dormant until the following year. These latter resemble in appearance the " dards " and " brindilles " which will be described later.

Productions on last year's wood. In the case of the Apple, the axillary fruit-bud formed upon wood of the current year usually remains to some extent adpressed to the shoot and in an upright position. Fruit-buds formed from a wood-bud of last year's growth are, however, different in appearance. They are

larger and more rounded; during the summer of their formation they are surrounded by a "rosette" of leaves (Fig. 11) and in the winter are seen to be seated upon a small stub varying from ¼-in. to 1-in. in length, and, of course, bearing the scars of the leaves that surrounded the bud during the summer (Fig. 11). This stub is the "lambourde" of French writers; and the stub plus fruit-bud is often called a "spur." (If the lambourde is terminated by a leaf-bud, the production is called by Bailey* a "leaf-spur.")

FIG. 11.

LAMBOURDE DEVELOPED FROM A WOOD-BUD OF LAST YEAR. (Newton Wonder.)

In addition to the lambourde, last year's wood-buds may give rise to four distinct types of shoot: the "Dard," the "Brindille," long weak infertile shoots ("bourgeons") and strong branches.

The dard (Figs. 12 and 13) is a common production on the Apple. It varies from 1-in. to about 4-ins. in length. Its lateral eyes are as a rule feeble, but the terminal bud may develop into a fruit-bud during the year of formation of the dard.

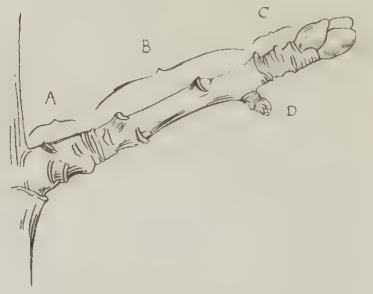

FIG. 12.

COMPOSITE PRODUCTION (on Lord Derby).

A. Infertile Lambourde developed during 1918 from a bud formed the previous year.
B. Infertile Dard arising from A in 1919.
C. Fertile Lambourde arising from B in 1920 (with flower 1921).
D. Minute weak infertile Lambourde formed during 1920.

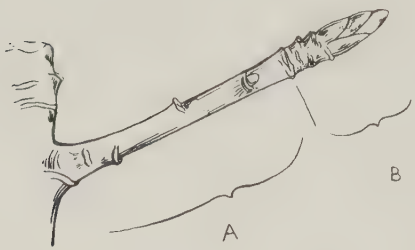

FIG. 13.

A. Dard.
B. Fertile Lambourde. (Early Victoria.)

The brindille (Fig. 14) is also a common production on both the Apple and the Pear, and if on a healthy tree which has reached a fertile state, is usually terminated during the year of its formation by a blossom-bud. Fruiting by means of terminal buds on brindilles and dards is a pronounced characteristic of most

* In "The Pruning Book."

of the standard commercial varieties of apple, and these terminal buds are in nearly every case larger and finer than blossom buds on axillary spurs or on " artificial " spurs. Moreover, the spurs resulting from the development of these blossom-buds are generally stronger and healthier than axillary spurs or artificial spurs.

The axillary buds of a brindille are, as a rule, feeble, though in some varieties such as Bismark and Lane's Prince Albert those towards the tip may develop into blossom buds during their first year. Both the dard and the brindille when arising from a leading shoot have a tendency towards a horizontal habit of growth—a habit which is often considered to make for fertility rather than wood production.

Brindilles of from 5 to 9-ins. in length are of the type on which terminal blossom-buds are usually formed during the first season. Shoots may be classed as brindilles when from 4 to 12-ins. in length.

It is worth noticing that there are certain morphological differences between the dard and brindille from last year's buds and the corresponding productions arising naturally from wood of the current year. The basal swelling is often

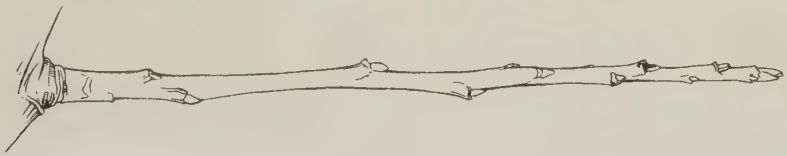

Fig. 14.
Infertile Brindille developed from a Wood-Bud formed last year.

hardly noticeable ; the stipulary eyes may be hidden beneath the leaf bracket, or poorly developed, or almost lost in the wrinkles at the base of the shoot ; bud scale scars are present ; and in the first inch and a quarter of the shoot are to be seen two or three scars of imperfect leaves (" folioles ") and as a rule (exceptions will be mentioned later) three leaf brackets which usually have very poorly developed buds in their axils, or no visible buds at all. (In Newton Wonder and Lord Derby these buds are often fairly well developed, however.) In the shoot or current year's wood which corresponds to a brindille or a dard, this basal inch with its three buds is, as it were, drawn out, so that there may even be a distance of 2-ins. from the base of the shoot to the first leaf and between each two nodes. On productions of this sort on the Pear the stipulary eyes may also be drawn out quite a distance, and are then no longer partly hidden by the leaf bracket.

A brindille on last year's wood if pruned to about 1-in., has therefore as a rule five buds left : three basal buds and two stipulary buds. A similar shoot produced on current year's wood if so pruned might have only its two stipulary buds.

The " long weak shoots " previously mentioned are like long brindilles. They have long internodes, tend to take up a horizontal position—though

this tendency is not so pronounced as in the brindille—and have in most cases poorly developed axillary buds. Terminal fruit buds are rarely found on this production, though in some varieties, notably Worcester Pearmain and James Grieve, they occasionally are present. (It is worth noticing in this connection that on these two varieties this class of shoot is of a sturdier type.)

Finally we reach the type of shoot which, on vigorous pruned trees, is extremely difficult to manage; the "branch" (sometimes called "rameau mixte"), the strong break given off just below the shoot required for a new leader. This production, of course, only differs from the leading shoot of a pruned tree in being a little less vigorous, and the same description will apply to both. It tends to grow upright, thus differing from the brindille, and if the tree is pruned back to it—as is done in the operation of "jointing back"—functions exactly as the leading shoot. Its basal area is similar to that of the brindille and long weak shoot, and in addition to this basal area it has other well-defined areas which it will be convenient to describe at this point.

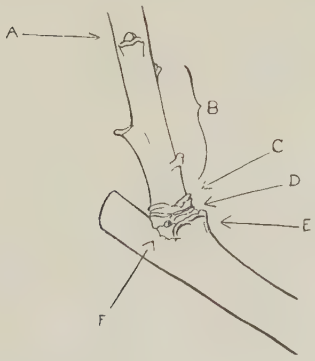

Fig. 15.

Base of a Shoot produced by a Wood-bud of last year (Gladstone).

A. First "dormant" bud.
B. Brackets of 3 basal leaves.
C. Scars of "folioles."
D. Scale scars.
E. Bracket of last year's leaf.
F. Stipulary eye.

Starting from the base of the shoot (Fig. 15) it will be observed that the basal swelling which was present in shoots from current year's buds is either not noticeable or feebly developed. Stipulary eyes are usually visible and above them is a ring of bud-scale scars. Above these scale scars and contained within the next $\frac{1}{4}$-in. will be seen, as in the brindille, a number, varying from one to three, of leaf ("foliole") scars which may be arranged in a ring round the shoot; these rarely have visible buds in their axils. Next comes an area about 1-in. long in which will be found, as a rule, three fairly well developed leaf-brackets (on James Grieve, Lord Derby, and Newton Wonder, four may be present, while on Lane's Prince Albert and Grenadier there may be only two): this area is called for the purpose of this paper the "basal area," and it will be seen later that its buds have peculiarities of behaviour of their own. It is, perhaps, hardly necessary to state that the number of "fairly well-developed leaf-brackets," with or without buds, that are encountered in the first inch and a quarter of these shoots may vary for reasons other than varietal. As in the case of the next area to be considered the basal area may, in some conditions, be telescoped, and, in others, drawn out. The next area, which may be called the "dormant area," varies in length according to the variety under

consideration; it may be from 3 to 12-ins. long. Its length is fairly constant on trees of the same variety growing under similar conditions, but it must be remembered that trees in dry districts will have shorter internodes. In conditions of ample water supply shoots tend to be drawn out, as one might draw out a piece of elastic, while in dry conditions they tend to be compressed. This area is the one made during the period of rapid growth in spring and its internodes are much longer than those in the basal area. Its buds, while better developed than the basal buds, are weak and tend to remain dormant in most varieties. Their strength and behaviour relative to the other buds on the shoot is a question of variety; their actual strength may depend on age of tree and environment.

The next area is even more variable in length than the preceding. It is the area in which there is a tendency to form axillary fruit buds during the current year, if the shoot is sturdy; or lambourdes during the following year if it is weak. Its internodes are usually shorter than those of the dormant area and the fact of a tendency towards fertility being present is possibly to be attributed to its having been made during the drier hotter part of the season when growth is slackening and when there is a greater tendency to store food-material.

With reference to this fertile area, mention should be made of the following facts. On unpruned trees of mature age, and sometimes on young pruned trees, a type of leader is produced differing from the normal shoot under description. It is characterised by sturdiness, and by short internodes in its lower areas. In such shoots axillary blossom buds may be produced right down to the basal area, so that the fertile tract extends over three parts of the shoot. The shortness of the internodes probably indicates that moisture supply has been restricted and that the early summer growth was slow. This type of shoot has been observed on most commercial varieties, and is not uncommon on Lord Derby and Cox's Orange. It is to be encountered where conditions, either of environment, or localised in the tree itself, are such as to induce short sturdy growth rather than long free shoots.

Finally, there remains the rest of the shoot, mostly growth made after midsummer. This also is variable in length, according to variety. Its buds are, as a rule, weak and have no tendency towards fertility. In one variety, Beauty of Bath, there is often to be found an extra inch or two of very late growth which is green and sappy and may retain a leaf or two during the winter, after the manner of the Nonsuch Paradise stock.

The significance of this division of the shoot into areas will be seen when the subjects of leader and spur pruning come to be considered. The brindille and the long, weak infertile shoot do not, with the exception of the basal area, show this well-marked differentiation of areas.

Development of Productions. Fruit Buds. The fruit bud of the Apple and of the Pear encloses, in addition to its flowers, leaves and an embryo shoot.

In this respect it differs from the blossom bud of the Peach, which contains a flower only, and from that of the Plum, which usually contains two flowers. Neither the Peach nor the Plum can, therefore, make further growth from a fruit-bud, whereas the Apple and Pear can do so.

This axis in the fruit-bud of the Apple develops into a production differing entirely in appearance from any other made by the tree, and with characteristics that are constant for any one variety. By the Americans it is called the "Cluster-base," and, by the French, the "Bourse." In English it has no specific name.

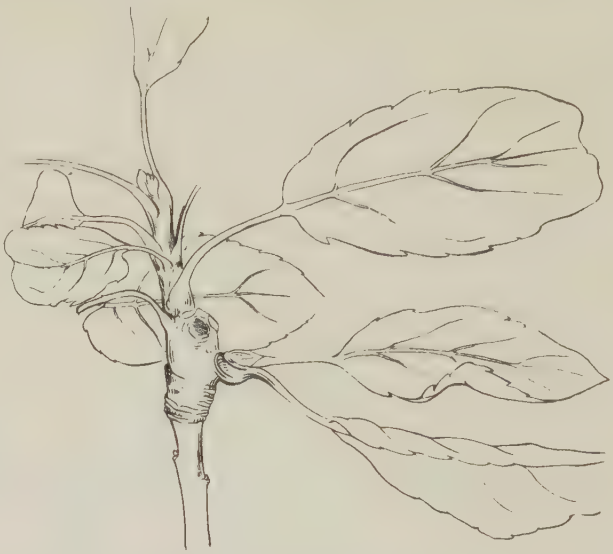

Fig. 16.
Bourse (Cluster-base) with Dard and Lambourde, developed from a Fruit-Bud formed last year. (Worcester.)

Fig. 17.
"*Bourse*," the two lateral eyes of which have grown out forming B, a fertile Lambourde, and C, a fertile Dard. A, scars of inflorescence.

As will be seen from the Figures 16, 17, 18, it is characterised by being short and swollen. It is usually soft and rather susceptible to damage at first and, though hardening with age, remains in the case of spurs—particularly artificial and axillary spurs—somewhat fragile and easily broken. If, however, the bourse is terminal and strong growth is made from it, it becomes in a few years practically continuous in appearance with the branch that bore it and is indistinguishable from it. On a spur it retains its characteristic shape for some years.

In the case of Newton Wonder the bourse is in the winter following its formation soft and swollen; in James Grieve it is strong, woody, and red in colour; in Beauty of Bath it is noticeably small in size; while in Gladstone it is thin and woody.

It is a type of shoot in which the growing point has been transformed into flowers and hence it is incapable of terminal extension. In the apple it is often found in winter terminated by a short stalk which bore the cluster of flowers or fruit during the summer. This stalk is usually missing in the case of the Pear ; it breaks off short and only the scar of it is seen.

Two lateral buds are almost always borne by the bourse of the Apple. A few varieties have, however, a tendency to carry three ; one of these varieties is Beauty of Bath.

The behaviour of the two lateral buds is dependent on the vigour of the tree, and upon its variety. Normally on trees which are in good health these lateral buds become blossom buds during the season of their formation. On enfeebled trees they may take two or more years to develop into fruit-buds. And on trees which are very vigorous both may give rise to long shoots. If the bourse has not borne fruit there is, of course, a tendency on the part of the lateral buds to make growth, such growths having usually a terminal fruit-bud.

Fig 18.

Bourse, which has produced two Brindilles after flowering. (Early Victoria.)

The basal area of a brindille arising from a bourse during the latter's first year is usually distinct from that of the normal brindille produced by a wood bud formed last year on a leader ; it may be drawn out, somewhat after the manner of the shoots arising from wood of the current year which have been already described, and contain few buds.

Many varieties tend always to make growth from the bourse (Fig. 18) ; such growths are usually fertile and these varieties do not usually exhibit the phenomenon of biennial fruiting unless enfeebled. Among them may be

mentioned Worcester Pearmain. Other varieties may only produce short lambourdes (Lord Grosvenor) from the bourses; hence these varieties in their maturity have very short spurs. Bourses which are terminal have usually a greater tendency to grow out than those which are axillary; this is shown very well in Worcester Pearmain.

The bourse, having flowered and formed lateral buds, may develop into a "spur." It will be seen that, since each bourse forms two buds, and since each bud may in turn give rise to another bourse, the ramifications of a spur may in time become very extensive.

An examination of mature unpruned trees will show, however, that short, much ramified, spurs are not common on the old wood of Apple trees. The production, in the case of many varieties, of dards and brindilles from the bourse results in the formation of organs having no resemblance to the short spurs of, say, Lord Grosvenor or Egremont Russet.

Lambourdes. The fertile lambourde, having a terminal blossom-bud, develops into a spur or a system of fertile dards and brindilles in the manner just described. An infertile lambourde may, on old or feeble trees, take two or more years before it forms a fruit-bud; or it may never form one. It is a question of vigour. On normal healthy young trees it rarely takes more than one year, though on certain varieties, to be enumerated later, it may take two or more.

Normally, this production rarely breaks into strong growth. Each year the bud unfolds a rosette of leaves and the lambourde increases in length by about half an inch. In an ordinary season it has apparently reached its resting state by the end of June, though subsequent wet weather may cause it to make further growth in spite of the fact that its terminal bud may have had all the outward semblance of a fruit bud.

Dards. An infertile dard normally behaves as a lambourde, lengthening a little each year until a terminal fruit-bud is formed. This shoot has, of course, several lateral buds which can easily be induced to develop by pruning.

Brindilles. The brindille with a terminal fruit-bud, during the season of its flowering and forming a bourse, usually develops a few lambourdes lower down which flower the following year. This does not occur, however, unless the tree is growing well; and in the case of such varieties as Worcester Pearmain and Irish Peace may not occur at all. Ranging through the varieties one finds every gradation, from brindilles with axillary fruit-buds formed during the first year, to those which only bear a terminal fruit-bud and rarely form axillary lambourdes at any time. In the latter case, however, the axillary buds often remain alive and capable of growth for a long period.

The infertile brindille does not as a rule grow strongly from its terminal bud; its usual procedure is to behave as though it were a lambourde. That is

to say, the terminal bud unfolds a few leaves, a small amount of growth is made, and finally a blossom bud is formed, while the axillary buds plump out and prepare to form lambourdes the following year. An access of vigour on the part of the tree may, however, cause both the brindille and the dard to make strong growth.

It should be mentioned that the brindille is characteristically a fertile production, both on the Apple and the Pear.

"*Long weak shoots.*" These are characteristically present on vigorous hard pruned trees of varieties such as Allington Pippin or Cox's Orange, which break freely when hard tipped. They may be described as thin elongated infertile brindilles which if left unpruned rapidly lose vigour. Their lateral, buds, being weak, have less tendency to form lambourdes than those of a brindille and usually remain dormant, growth taking place the second year from the terminal bud only.

"*Branches*" ("rameaux mixtes"). These also are characteristic of pruned trees and, if left unpruned, will be found in their second year behaving like the leader of an unpruned tree, both as regards terminal and lateral activity.

Leaders. The leading shoot of a young unpruned tree differs from that on a pruned tree as regards the number of lateral shoots made in its second year from axillary buds. Whereas the pruned leader may make from two to six laterals, the unpruned leader may simply grow straight ahead from its terminal bud, forming no lateral shoots at all ; or it may make from one to three lateral growths. This behaviour is, of course, influenced by the vigour of the tree—there is a better chance of lateral growth being made on a strong unpruned tree than on a weak one—but to some extent it is also affected by the factor of variety.

The lateral breaks made by an unpruned leader during its second year are as a rule much inferior to it in vigour, being usually dards or brindilles ; moreover they tend to produce terminal fruit buds if the tree has reached a bearing age.

Eventually, about the third or fourth year in the case of healthy trees on dwarfing stocks, the leader may bear a terminal fruit-bud. Terminal extension then ceases and the leader forks, the two lateral buds of the bourse growing out to make the fork. These two lateral shoots themselves usually bear terminal blossom-buds and fork again. This method of growth is very clearly shown by Worcester Pearmain. Variations will, of course, occur if the bourse has three lateral buds ; or, again, if the tree is too weak to develop more than one lateral bud into a branch.

A different behaviour is shown by such varieties as Lord Derby and Rival the leading shoots of which may grow on for many years without forming a terminal fruit bud, thus contributing to a habit of growth which contrasts strongly with that of Worcester Pearmain.

Below the area containing lateral shoots on the unpruned leader are produced, in area 2, lambourdes which may be fertile or infertile. On Lord Derby, for instance, they may take three years before maturing a blossom bud, while on other varieties only one year may be necessary.

The greater part of area 3 usually continues dormant, as does the basal area (area 4) ; these two giving rise to the large percentage of bare wood which is found on unpruned trees of many varieties during their first five or six years, that is to say, while strong growth is being made.

The amount of bare wood varies with the variety of Apple, other conditions being equal. On Lane's Prince Albert, where the fertile area on which axillary fruit-buds may be developed during the first year is very large (so that there is little or no dormant area) bare wood does not form a high percentage of the tree. The same applies to Early Victoria, which has also a relatively small dormant area.

Further development of leading shoots on an unpruned tree continues in the manner indicated above, so long as the tree is vigorous. As it reaches maturity, however, the annual growth becomes shorter and in some varieties shows an increasing tendency to form axillary fruit buds during the year of its growth. There may be a gradual change in appearance and characteristics from the vigorous leader which has been described to a type of shoot more resembling a sturdy brindille, usually of a fertile character. As this change progresses the division into areas becomes less marked and the behaviour of the axillary buds more erratic.

So far the development of the various productions has not been traced much beyond the second year. But the habit of the natural tree depends, of course, to a great extent, on the behaviour of these productions in future years. Eliminating the question of sturdiness or whippiness of growth and the question of vigour, it will be seen that the characteristic appearance of an unpruned tree must depend very greatly on the behaviour of bourses, on the method of furnishing last year's wood and on the subsequent behaviour of this furnishing.

It should be added that the above observations on the different productions refer to healthy trees of normal vigour. Variations in the length of internodes and in the length of different areas will obviously take place according to diminution or increase of vigour. For instance, on a strong brindille of a given variety, the basal area may be about 1-in. in length, which is the normal size ; but on a weak brindille on an old tree of the same variety, the same area may be no more than half an inch in length. Hard pruning to a given length in the latter case would, therefore, leave more buds than in the former.

(For facilities to make detailed observations the writer is much indebted to the East Malling Research Station ; to Mr. E. A. Bunyard ; to Mr. Waghorn, of Beltring ; and to Mr. Faircliffe, of Burwell, Cambs.)

THE APPLE AND PLUM CASE BEARER

(*Coleophora nigricella*, Stgch.)

AND ITS TREATMENT.

By F. V. THEOBALD, M.A.

Some twenty years ago Mr. Howard Chapman, a large grower on the banks of the Thames at Greenhithe, pointed out to me the damage being done by some small "Case-bearing" larvæ, an unknown *Coleophora* at that time, and he expressed the opinion that if they increased much more they would become a serious pest to both Apples and Plums. These insects I never succeeded in identifying but the larval cases and moth were figured in the "Insect and Allied Pests of Orchard, Bush and Hothouse Fruits," in 1908 (fig. 152, p. 196). Some fifteen years passed and no serious damage was ever seen or reported due to these "Tineid" moth larvæ.

But in 1918 and again in 1919 a few enquiries were received concerning the economy of these insects from East Sussex, Kent and South Devon. In 1918 it was present in harmful numbers in some Apple plantations at Capel in Sussex. In 1919 it quite defoliated some Plum and Apple trees at Wateringbury in Kent. In 1920 two instances of serious damage occurred in Kent near Tonbridge and Sittingbourne and many minor attacks were either observed or reported from the same county. In the same year Mr. Petherbridge records in the Monthly Reports sent to the Ministry of Agriculture that "A *Coleophora* on Apples was much worse than usual in East Anglia," and the Ministry received information from Ledbury that the moth larvæ referred to in this paper had done much damage to foliage; also that a bad attack had taken place in Hertfordshire in the same year. In 1921 it was very injurious in the Marden

Fig. 19.

Damage by *Coleophara nigricella* to Apple Blossom Trusses and Leaves.

a. Larval cases (reduced ⅓).

district of Kent, in Thanet and in several other Kent localities. In April and May of that year Mr. Chittenden says that "*Coleophora nigricella* and *Coleophora anatapenella* were the only two serious larvæ that did damage to Apples in late April and May at Wisley." The Ministry of Agriculture also received information that much damage had been done in the Preston area in June and Mr. Walton observed it at Mostyn in Flintshire, North Wales.

In 1922 it occurred in destructive numbers near Sandwich and Ash in Kent, and it was observed in great abundance in several orchards in other parts of the county.

It was noticed in Hampshire on Cherries in 1922, and found to be generally distributed, but was not causing much trouble.

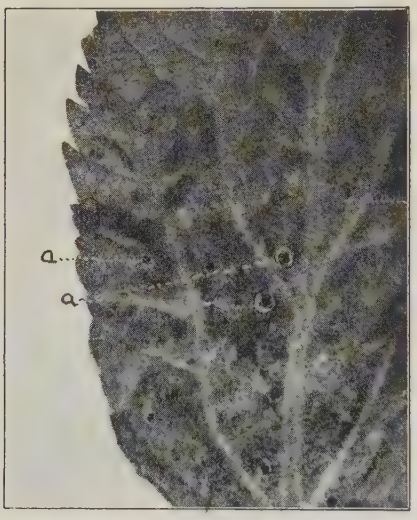

Fig. 20.
Piece of Apple Leaf, showing Holes made by Larvæ (a).

Records of its harmful nature also come from Worcestershire and West Sussex.

It is found over Northern, Middle and Southern Europe and in Japan.

Stainton in his "Manual of Butterflies and Moths," (Vol. II., p. 385, 1859), records it from Alkham, near Dover; Kingsbury, Middlesex; Pembury, Kent; Bristol; Cambridge; Darlington; Birkenhead; Manchester; Newcastle-on-Tyne and Scarborough.

In "The Insects of Kent" (Victoria County History), it is stated to be generally distributed in the county, and this is according to what I have observed, and also in Sussex, especially East Sussex.

Many other records could be given to show the wide distribution of this insect, which is innocuous in small numbers, but which may, as has occurred in recent years, become a serious enemy of the fruit grower and gardener.

The worst attacks I have seen were in 1920 in the Tonbridge and Sittingbourne districts, and this year (1922) near Ash and Sandwich. In the two former instances some plantations were practically defoliated by this insect.

The *damage* done is mainly to the buds and young leaves, very soon after the buds burst, and when any amount of the larvæ occur at this period the foliage and blossom trusses are completely destroyed, as shown in Fig. 19. Later, when the leaves are maturing, small pale patches are readily noticed on them, the number depending upon the quantity of "Case bearers" present and length of attack. Total destruction of a leaf has been noticed to occur in a week

when only two or three insects are feeding there. Attacked trees show a marked scorched and shrivelled appearance. The blossom may also be eaten. These "Case bearers" may even attack the fruit both when young and when nearing maturity; this has especially been observed in Cherries when green and small; each fruitlet is spoiled even by a single larva.

The larvæ do not feed on the surface of the leaves, but as shown in Fig. 20, they cut out small round holes, usually below the leaf, but now and again I have observed them above in equal numbers. The epidermis only is cut through, and to this aperture the snail-like case of the larva is attached and the larva then partly emerges out of its case and feeds between the upper and lower skins, scooping out the internal tissues and thus causing a pale, blister-like spot of more or less irregular shape. After a time the larva may move on to another spot and so on until the leaf is ruined, as shown in Fig. 21. The very marked damage shown in the photographs reproduced here cannot very well be confused with any other Apple and Plum insect pests work.

Fig. 21.
Leaf of Apple Mined by *Coleophora nigricella* Larvæ.
a. Mature larval case (reduced ⅓).

Description of Adult, Egg, Larval Cases and Larva.

Adult. The moth is like a small dark Clothes Moth, and is about 12 mm. in wing expanse. The wings are narrow and the hind pair have long fringes. The front wings are black, a few specimens may have some scattered paler scales; the hind wings are slightly paler and the long fringes deep grey. The antennæ are pure white with prominent black rings. The legs are fuscous grey (Fig. 22).

Fig. 22.
Adult *Coleophora nigricella*.
Enlarged and line showing natural size.

The *ova* are pale creamy white to white, very small, almost oval and with marked sculpturing (Fig. 23). The *Larval cases*, when young (Figs. 24 B. and 25 b.) vary from 1.5 mm. to 4 mm. in length according to age; they are curved and vary in colour from bright brown to dull grey, the hinder part of the case being darkest; the

circular opening of the case is pale. The case later is remade and becomes straight and cylindrical, almost cigar-shaped and about 8 mm. long; these fresh " cases " vary from brownish black to deep brown; when old they may become tawny brown to tawny yellow or dull ochre and have a dead appearance (Figs. 21 a. and 25 a.).

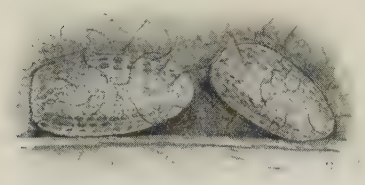

Fig. 23.
Eggs (greatly enlarged).

The *larva* (Fig. 24 A.) is pale dusky pink to dull red or greyish-red with a dark chitinous head; a dark chitinous pronotal dorsal plate, and a dark anal dorsal plate; the legs are dark brown and there are a few short dorsal hairs apically and one or two ventral ones; prolegs are absent; the segments marked and the body somewhat swollen posteriorly. Length 4 to 5 mm., when mature.

Life-History.

The moths, as far as my observations go, hatch out between July 1st and July 30th. In one instance a few kept in the laboratory appeared on June 27th, and in another a single female emerged as late as August 14th. According to Stainton, the moths occur in June and July. The moths lived for from ten days to three weeks. Eggs were laid under the leaves, especially the topmost leaves of the shoots, but many below. They are embedded amongst the leaf hairs. They hatched in August and some as late as August 24th. The egg stage lasts about two weeks. The small larvæ are at first free living and feed on the surface tissue, and then burrow into the leaf tissues, but do scarcely any noticeable damage. Soon they become covered with a coating of leaf tissue and silk, and before winter assume the curved case-form shown in Fig. 24 B. This case, at first small, further increases in size before the larva hibernates. For the winter the case is attached by silk near the base of buds and there the larva remains until the early Spring.

Fig. 24.
A. Larva taken from case.
B. Larva in first case on leaf.
x. 7.

In Spring, they soon become active and are ready to feed on the

buds and on the young, unfolding leaves. By May some of the larvæ have reached their final stage, and then the curved case, which has grown in size is re-made as a more or less straight, cylindrical tube which is to be found on the leaves or fruit, but most of which soon seem to crawl to the wood after a feeding period, before the moths emerge (Fig. 25 a.). When nearly mature, the larvæ often seem to release their hold of the leaf and by means of a fine strand of silk hang in the air, swaying backwards and forwards in the wind, and if the wind is strong many get wafted on to other trees near by. In this latter way the insect is spread from tree to tree over a plantation. The insect is of course also disseminated by the winged moths, which, however, do not appear to fly far. Artificially they are spread by means of nursery stock.

So far I have never bred a single parasite from this *Coleophora*, but a few minute Chalcid have been found in Canada on a related species.

A very similar insect attacks fruit trees in America—*Coleophora fletcherella*. Fernald, which has been monographed by M. V. Slingerland (Bull. 93. May, 1895, Cornell University Agricultural Experiment Station, Ent. Division. The Cigar-Case-Bearer in Western New York). The strange larval working in the "case" formation is the same here as in America and for these interesting details the reader is referred to that article.

Plants Attacked.

Although Apples are mainly attacked and no variety seems to be immune, the Apple is not the only food plant. Plums frequently suffer seriously and also Damsons. Cherries also are often seen to have these "Case-bearers" on them, and the fruitlets now and then are destroyed, but I have never known of really serious harm to the Cherry. It is frequent on the Sloe and Bullace in hedgerows and woods. On the Pear it is uncommon in this country. On one occasion I found it on Medlar. It is also recorded on Hawthorn; but any way, in Kent it is not common on it, and it has been found on *Betula* or Birch trees.

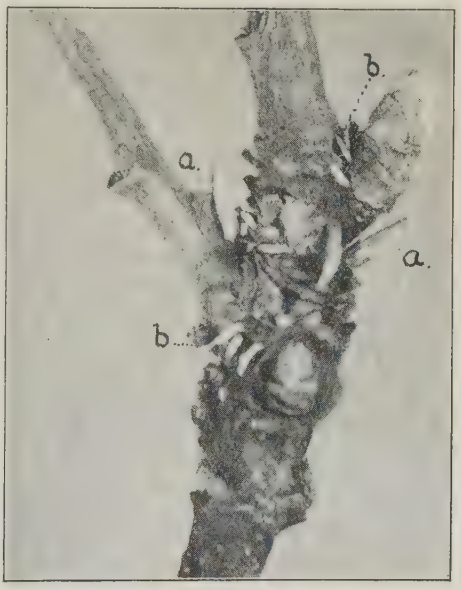

Fig. 25.

Larval Cases of *Coleophora nigricella* in Winter.

Live over-wintering larvæ b.; old cases a.

Treatment.

Very similar Case-bearing *Coleophora* occur in Canada and the United States, and it has been said that these insects cannot be destroyed by spraying when enshrouded in their snail-like coats in winter.

Experiments conducted in England in 1920 and 1921 show that it can quite well be controlled in the " Case-bearing " stages in spring, similar results having been obtained by Slingerland in 1895.

Winter spraying was tried and found to be of no use. The following Winter washes were experimented with : (1) Hot Lime ; (2) Lime Sulphur ; (3) Strong Paraffin Emulsion ; (4) Lime and Paraffin ; (5) Caustic Soda and (6) Strong Napthalene Soap Emulsions. With all six no deleterious effect was noticed on the firmly fixed hibernating insects. None of the washes proved caustic enough to touch the larval cases or even to dissolve their attachment to the wood. In one experiment 25 lbs. of Caustic Soda was used to the 100 gallons of water. This agrees with the American results.

For the Spring, Arsenate of Lead and Calcium Arsenate were both used in April and again in May. None of the larvæ suffered from the effects of these stomach poisons. In one plantation the bailiff has used Paris Green, but it had no effect. Slingerland, however, records that this met with success in America.

Arsenical washes failing, use was made of (1) Nicotine, (2) Nicotine and Soft Soap, and (3) Nicotine Sulphate and Soft Soap. Experiments were carried out in three localities. The results showed that all three destroyed a very large per. centage of the larvæ in all stages.

The amounts used finally were as follows :—

A. Nicotine, 96 per cent., 1 oz. ; Water, 10 gallons.

B. Nicotine, 96 per cent., 1 oz. ; Soft Soap, ½-lb. ; Water, 10 gallons.

C. Nicotine Sulphate, 1 oz. ; Soft Soap, ½-lb. ; Water, 10 gallons.

The results obtained with A were too variable to be serviceable. If applied when the cases were wet, as many as fifty-seven per cent. of the larvæ were killed, but if dry, the wash ran off the insects and leaves and very few succumbed.

With both B and C, the soap appeared to hold the fluid on to the " cases " and leaves and enabled the nicotine and its fumes to penetrate into the holes formed by the larvæ and so come in contact with the naked parts of the caterpillars, and thus affect them injuriously both by passing into the spiracles and so acting on the nervous system and also as a stomach poison, through the larvæ devouring it with the internal leaf tissue.

The only difference seen between the action of the pure nicotine and the nicotine sulphate was that the latter took as much as forty-eight hours longer to have the same effect as the pure nicotine and soap.

Against this will be seen by the following record that the killing power was slightly higher and that the effect on some Aphides was much greater.

A.	B.
Nicotine and Soft Soap.	*Nicotine Sulphate and Soft Soap.*
Tree 1, 85 p.c. Case-bearers killed	Tree 4, 92 p.c. Case-bearers killed.
Tree 2, 83 p.c. ,,	Tree 5, 90 p.c. ,,
Tree 3, 80 p.c. ,,	Tree 6, 94 p.c. ,,

On trees 2 and 4 were several young colonies of *Aphis* (*Dentatus*) *malifoliæ*. of Fitch, the so-called "Blue Bug"; the young leaves being well curled in several patches by them.

On Tree 2, only 60 per cent. of the aphides died. On Tree 4, the death-rate was as high as 94 per cent. The count was made from just under five days from the actual spraying. The weather was fine with a hot sun and although the rapidly volatilising nicotine killed the Mother Queen Aphides and the young, later-hatched young expelled from the dying viviparous female were not killed and they matured. The more slowly volatilising Nicotine Sulphate evidently destroyed these later, as well as the *Coleophora* larvæ.

The Nicotine Sulphate *must* be mixed with Soft Soap.

It may in conclusion be mentioned here that the amount of *pure* Nicotine was, in two instances, reduced to ½ oz. to 10 gallons, but the results were not satisfactory.

CONTROL OF THE APPLE BLOSSOM WEEVIL.

By HERBERT W. MILES, B.Sc. (Bristol).

From the University of Bristol Agricultural and Horticultural Research Station, Long Ashton.

The Apple Blossom Weevil, *Anthonomus pomorum*, Linn., is one of the most serious pests with which the fruit-grower has to deal, in that its life history is one offering little scope for the application of preventive measures and the adult Weevil seems singularly unaffected by spraying treatments. During the last two years, through the kindness of Professor B. T. P. Barker, M.A., and with the co-operation of Mr. A. H. Lees, M.A., the writer has been able to study the habits and life history of the weevil and to make preliminary trial of certain methods with the idea of securing effective control. Since the detailed account of the life-history is appearing elsewhere, only a brief account will be given here in so far as it affects control measures.

Life History.—The adult Weevils spend the winter in bark crevices or under the rough bark of orchard trees, in cankered areas, amongst dead leaves or in the soil. When the buds show green at the tips, about the end of March, the Weevils leave their winter quarters and crawl upwards to the developing buds, and, rejecting the surface tissue, thrust the rostrum, or snout, downwards, with a rotatory movement of the head, towards the growing point where they suck the plant juices which are accummulating in that region. As a result of this spring feeding the sexes are stimulated, and mating takes place. Now follows a period of alternate feeding and resting, the Weevils hiding in any available shelter. This goes on for four or five weeks when the females are ready for egg laying and the inflorescence buds have reached the " cluster-bud " stage of development. It is at this stage that egg-laying takes place ; the female, after drilling a hole into the flower bud, excavates a cavity in the anther lobe and reversing her position deposits the egg into the prepared cavity by means of her extensile ovipositor. The whole operation takes from twelve to fourteen minutes. The holes are not sealed up, as was formerly thought, by the female but a sappy exudate from the damaged tissue mixes with the pubescence of the calyx and effectively closes them.

The eggs hatch in from eight to thirteen days, the time varying with the temperature. The young larvæ feed first on the anthers, later on the filaments and styles, and finally, if not fully fed, attack the surface of the receptacle. They take about a fortnight to mature, and then pupate inside the capped blossoms.

The young adults emerge from the capped blossoms about eight to ten days after pupation, usually some time in June, towards the beginning of the month in early seasons but towards the end in late ones. They then feed for about a month on the under surfaces of the leaves of Apple, Pear and Plum, discarding the epidermis and eating the mesophyll or internal leaf tissue. When fully fed these young adults seek Winter quarters and overwinter in any easily available shelter.

PREVENTIVE AND REMEDIAL MEASURES.

FROM time to time various measures for the control of *Anthonomus pomorum* have been recommended by the Ministry of Agriculture. In the Leaflet dealing with this pest, under " Methods of Control " the following appears :—" The insect when young is protected within the ' capped blossom ' ; when adult it appears to feed little—or at all events, not in such a manner as to make a lead arsenate spray of much use. It spends the winter in various places, always well concealed, and winter treatment cannot be wholly effective.

" (1) Nevertheless, in most orchards something, and in many, much can be done in winter. In the first place, if the trees are mossy and the trunks encrusted with loose bark many Weevils will hibernate on the trees and a winter wash, or later a lime wash, will destroy many of them ; recent reports tend to show that late lime-washing is the best remedy against the Weevil. The burning of all rubbish and the cleaning of hedge bottoms and ditches will also be helpful, as will the cultivation of the ground underneath the trees.

" (2) In France it has been found practicable to reduce the numbers of the beetles by shaking them off the trees just before they lay their eggs. A large sheet is spread under the tree which is shaken or tapped with a stick, and the beetles which fall down are tipped into a pail containing a little paraffin.

" (3) In small orchards or where the trees are young it is worth collecting the capped blossom by hand before the bettles emerge.

" (4) In connection with this hand-picking the possibility of increasing the number of ichneumon parasites is worth consideration. If the collected ' capped blossom ' be placed in the orchard in a box with a muslin cover of a certain mesh (about one-thirty-second inch) the Weevils will be imprisoned while the ichneumons will be able to escape. It has already been pointed out that the ichneumon is an efficient enemy of the Weevil, destroying 25 per cent., and if capped blossoms could be collected over a wide area and the ichneumons released, this percentage might be considerably increased. In France results obtained by this method are said to have been distinctly hopeful.

" (5) The Weevils seek winter quarters fairly early in the summer and they may then be trapped by means of bands of sacking tied round the trunks of the trees—as for Codling moths. The band should be in position by the beginning of June and should be removed and be burned in the autumn. This method of control may prove of more value than has hitherto been supposed.

" (6) Apart from winter washing, no spray has yet been proved to be of much use and spraying should only be tried experimentally."

(1) Winter Treatment.

With regard to winter treatment, the cultural recommendations are undoubtedly sound. Cultivation beneath the trees, cleaning of hedge bottoms and ditches and burning all heaps of plantation and orchard refuse is an excellent procedure; for, while destroying any Weevils hibernating in such quarters, it means that year by year more Weevils will winter on the trees where they can be attacked by spraying. Winter washing and lime washing as spray treatments, however, leave much to be desired, in that the majority of the Weevils can readily withstand 2 per cent caustic soda, the usual caustic winter wash, and following a lime-wash numbers may be seen feeding in spring with masses of adherent lime. A beneficial action of a lime wash may be the retarding of the bursting of the flower buds, which results in a sudden burst of flower before the weevil larvæ hatch in the buds or when they are still so small that they perish.

Certain preliminary spraying trials have been conducted at Long Ashton which took the form of :—(*a*) Laboratory trials and (*b*) Plantation trials—*i.e.*, trials under field conditions.

Laboratory Spray Trials.

The substances used were selected for their known killing power, or because they have been previously recommended : the sprays included :

1. Caustic Soda.
2. Lime Wash.
3. Soft Soap, Paraffin and Nicotine.
4. Soft Soap and Carbolic Acid.
5. Carbolic Acid.
6. Carbolic Acid, Soap and Paraffin.
7. Paraffin Emulsion.
8. Paraffin Emulsion and Nicotine.
9. Copper Stearate.

The following table gives the sprays and their efficiency.

Spray.	Materials.	Amounts.	Efficiency.	Remarks.
Caustic Soda	Sodium Hydrate	% .2.	% 10 killed *	Unsatisfactory. Killing power too low
Lime Wash	Lump Lime (unslaked)	20	43 ,,	Fresh lump lime is necessary
Nicotine Paraffin Emulsion	Soft Soap Paraffin Nicotine	1.5 2.0 .02	30 ,,	Action of Nicotine anæsthetizing. Insects often recover after a few hours.
Ditto	Soft Soap Paraffin Nicotine	1.5 2.0 .04	90 ,,	Spraying done in Laboratory
Ditto	Soft Soap Paraffin Nicotine	1.5 2.0 .03	0 ,,	Spraying done in open air.
Soap and Carbolic Acid	Soft Soap Crude Carbolic Acid	.25 2.5	100 ,,	Weevils killed within 10 minutes Unpractical
Carbolic Acid	Carbolic Acid	.5	0 ,,	Inefficient
Carbolic Acid and Soap	Carbolic Acid Soap	.5 .5	0 ,,	Inefficient
Carbolic Acid and Soap	Carbolic Acid Soap	1 .5	0 ,,	Inefficient
Carbolic Acid and Soap	Carbolic Acid Soap	1.5 .5	0 ,,	Inefficient
Carbolic Acid, Soap and Paraffin	Carbolic Acid Soap Paraffin	1.5 .5 2.5	100 ,,	Kills by Paraffin only.
Paraffin Emulsion	Soap Paraffin	.5 15.	100 ,,	Emulsion unstable. Kills by Paraffin
Paraffin Emulsion and Nicotine	Soap Paraffin Nicotine	.5 15. .04	100 ,,	Nicotine superfluous

From the foregoing the only spray selected for field trials was the unstable Paraffin Emulsion consisting of :—

.5 per cent Potash Soft Soap.
15 per cent. Paraffin.

This Emulsion required thorough emulsification and needed to be constantly agitated while spraying was in progress. When the liquid came into contact

* Calculated from number of weevils subjected to treatment and number killed.

with the bark the emulsion broke down and the paraffin, being liberated, " crept " into all bark crevices and canker spots wetting them most effectively.

For ease in preparation in the field, potash soft soap in liquid form (50 per cent. soap) was obtained; this gave a speedy mix and was found very satisfactory. Several trees, at different times during the autumn, winter and spring, were sprayed at Long Ashton, and within a quarter of an hour after the application, the dead Weevils could be found in the bark crevices. From evidence collected at Long Ashton during 1920-21 it was decided to make a trial further afield, and, if possible, in a grower's plantation. This trial, arranged by Mr. R. C. Gaut, M.Sc., the County Organiser for Worcestershire, was undertaken on the plantations of Mr. D. E. Tower, of Pershore, who kindly lent his plantation and spraying apparatus. Thus on March 17th, 1922, a portion of a plantation containing fifty-five apple trees and a few Damson and Plum trees was sprayed. The amount of spray used was 20 gallons made up as follows :—

Paraffin	2 gallons	10 per cent.
Potash Liquid Soft Soap (50 per cent.) ..	3 lbs. approx.	.83 per cent. * (actual soap).
Water	18 gallons	

The Apple trees were of bush form on Paradise Stocks; the short trunks bore the remains of old grease bands and portions of rough bark and some of the lower branches had canker spots, and in these situations many Weevils were hibernating. The spray was applied with force and directed principally on the trunks and lower portions of the branches; the 20 gallons sufficing for sixty-three trees or roughly three trees per gallon. About two hours after the application, dead Weevils were found in the crevices. Weevils only partly wetted with the spray were still alive, but died within about two days.

Several lessons were learnt from this trial ;—

(*a*) That 10 per cent. Paraffin killed quite effectively.

(*b*) That to economise in spray fluid it would be advantageous to apply with a Knapsack spraying machine, directing the spray only on spots likely to harbour the Weevil.

(*c*) Great difficulty was experienced in keeping the spray in emulsion.

With regard to damage to trees by Paraffin, it was decided to test the effect on trees at Long Ashton before conducting field trials in case any deterimental effect should result. Four trees were put into cold storage at a temperature of 34°F. in December 1921, and after a month's treatment

* Amount varies with the hardness of the water.

they were exposed in the open air for about a week and then subjected to the warmer temperature of the greenhouse until growth commenced and the bud scales were seen to be lifting. This was the dormant spray period and the Paraffin Emulsion was applied on January 16th, and a fortnight later, when the buds were showing green at the tips, the second tree was sprayed. In neither case were any ill effects noted, and thus it was concluded to be quite safe to make field trials. In March, 1922, a plot of about twenty bush trees was sprayed at Long Ashton, and in no instance was any damage to the buds noticed.

While discussing spray treatments attention must be paid to the action of lime-sulphur. This spray has a peculiar drying effect and, where used annually as an insurance spray, causes the bark to assume a characteristic dry nature, which extends to the crevices and canker spots rendering such shelters, for the most part, unsuitable as hibernating quarters for Anthonomus since this insect prefers quarters where there is a certain degree of moisture maintained.

From the foregoing account it is suggested that spray treatment versus the Apple Blossom Weevil might take the form of :—

(i.) Cleansing the trees from moss and lichen with a 2 per cent. Caustic Soda Winter Wash and scraping off all rough bark and old grease bands.

(ii.) Spraying annually with lime-sulphur to develop the drying bark state.

(iii.) Spraying at the dormant and delayed dormant stage with the unstable Paraffin Emulsion. This would only be done when numbers of insects were found hibernating on the trees and a bad season was expected.

(2) JARRING.

Jarring, in spring when the Weevils are egg-laying, has been tried by many growers but takes considerable time, moreover, in the writer's experience many of the Weevils when " jarred off " and finding themselves falling, spread their wings and fly back into the trees. Where a few trees only are to be treated jarring with a padded mallet or stout stake might be adopted with fair results.

(3) and (4) COLLECTING CAPPED BLOSSOMS.

Collecting the capped blossom can be done with very good results where adopted on bush trees or young trees which can be easily reached from the ground ; where steps have to be used, however, it becomes more laborious and takes considerably longer. The best time to collect capped blossom is just when the young apples are seen to be forming and the calyx is closing.

The parasites of Anthonomus should always be encouraged and the best means of increasing their number is to keep the collected capped blossom and

arrange to liberate the parasites as they emerge. This can be done by employing muslin of such a mesh that the parasites escape through it while the Weevils are retained, or else by fitting boxes with muslin lids which are raised at certain intervals to allow the Ichneumons to escape.

(5) Trapping.

Lees* mentions certain experiments done in the Tyrol in 1897-8 in connexion with banding. The bands, consisting of corrugated paper, etc., were fastened on the trees with wire or string and were examined each month when the returns of weevils caught were as follows :—

1897.									1898.			
Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
5	1785	4	4	3	9	164	982	223	24	18	3505	2561

These figures seemed so satisfactory that it was decided to put on a few bands in order to get some indication of the whereabouts and movements of the weevils, and to circulate among certain growers in Worcestershire the outlines of a scheme for the trial of banding :

Several growers undertook the trials but the only satisfactory result was secured by Mr. D. E. Tower, F.R.H.S., from whom the following figures were received :—

Date of Examination.	March	April		May			June
	30th	9th	25th	6th	17th	26th	5th
Number of Weevils caught	56	63	23	130	36	21	8

Mr. Tower noted that smooth barked trees when banded gave poor results, that examination in the early morning gave better results than later in the day, and that the weevils selected the south side of the trees for shelter.

From the above figures it will be seen that the greatest numbers were taken in early May and would probably consist of spent females. The most important period for banding would be either late March and early April, when the weevils seek shelter after their first spring feed and pending the ripening of the ovaries, or from June onwards to catch the young adults when they are fully fed.

With regard to spraying, other than winter treatment, it was thought something might be done with Lead Arsenate in an attempt at poisoning the

* 1921 Annual Report, Agricultural and Horticultural Research Stn., Long Ashton.

Weevils. Branches of Apple were sprayed with Lead Arsenate (4 lbs. per 100 gallons of water) and the Weevils sleeved on to them ; the result however was disappointing for they rejected the surface tissue of the leaves and fed on the mesophyll.

From the foregoing discussion it will be gathered that no single operation can be considered as totally effective in controlling the Apple Blossom Weevil and, until the results of further trials are forthcoming, any of the control measures as recommended by the Ministry of Agriculture, if used in conjunction with the unstable paraffin emulsion herein discussed, can be safely employed to keep the Weevil in check and, if the special treatment selected is adopted annually for several years, the benefit should be increasingly felt.

SPRAYING FOR THE CONTROL OF THE LOGAN BEETLE.

By G. S. PEREN.

In continuation of the work reported in the Annual Reports of the Research Station, Long Ashton for 1920 and 1921, a further trial of arsenate of lead or the control of the logan beetle was carried out this year on lines similar to those of last year's experiment.

Twelve rows of logans were used. Three-quarters of each row were sprayed and the remaining quarter left as control.

The first spraying was applied when approximately one third of the blossom was out, the second, when two-thirds were out, and the third when the bushes were in full bloom.

The following formula was again used :—

Arsenate of lead	4 lbs.
Water	100 gallons.
Pressure of application	125 lbs. per square inch.
First application	May 31st.
Second application	June 3rd.
Third application	June 10th.

A fine nozzle was used and the spray driven right into the blossoms.

The results obtained are given in Table I., and show that the sprayed berries averaged 2.5 per cent. infected, while the unsprayed berries averaged 9.1 per cent. infected. The last four pickings may, however, be again disregarded, being light and of little value, thus giving an average of 1.9 per cent. infected for the sprayed lot and 8.3 per cent. infected for the control.

The figures for the percentages infected for the sprayed berries do not show the more or less regular rise of those of 1921 but tend to be erratic. The same figures for the unsprayed berries, however, show, with the exception of the heavy infection at the first picking, a rise to 12 per cent. on July 25th, followed by a decrease to 3 per cent. on August 9th, again followed by a rise to 12 per cent. on August 21st. These figures for the control plot behave very similarly to those in the same column for 1921, the chief differences being the higher initial figure and the greater increase at the end of the season.

All the percentages infected are low when compared with the corresponding figures for 1921 and 1922. This is probably due to two causes—firstly the fact that the major portion of the loganberry plot is receiving a spray which is rapidly exterminating the beetle population and thus diminishing available material for

the trials, and secondly to the reported " off " year for logan beetles. The extent of this " off " year is not known, but a certain number of reports have indicated that the beetle was not so prevalent in some localities as last year. In order to test more fully the efficiency of the sprays, the control area for 1921 was this year brought into the sprayed portion and an area which was sprayed last year was this year used as a control. It is of course quite possible that this procedure lowered the figures for this year's control.

The results for the last three years are as follows :

	Sprayed.	*Unsprayed.*
	per cent. infected.	per cent. infected.
1920	15.0	24.0
1921	4.9	19.8
1922	2.6	9.1

and it is reasonable to suppose that the figures for 1920 would have been lower had three applications instead of two been made. From these figures it appears evident that arsenate of lead is quite reasonably effective in controlling the beetle. In addition, the figures for 1922 strengthen the hope expressed in the previous report that after three years efficient spraying, it will be possible to dispense with spraying for one or two years provided there are no sources of infection near by, such as an old Raspberry patch or, of course, other Loganberries.

The results are considered sufficiently good to warrant the commercial application of this treatment and so in conjunction with further trials to thoroughly establish proofs, it is proposed to test as deterrents to bees and other pollinating insects, various substances which can be mixed with arsenate of lead. The danger to bees is of course the great drawback to the use of arsenate of lead when the blossom is out. A few dead bees have been noticed in the plantation after spraying, but as the action of the poison is not instantaneous, a certain number may have died after leaving the plot ; however, a stock of bees belonging to the Station have shown no casualties, although only some two hundred yards from the plot containing thirty perches of sprayed bushes.

The set of the fruit has each year been very satisfactory and in no way impaired by any casualties in the ranks of the pollinating insects.

In addition to the work with arsenate of lead, a very strong paraffin emulsion as suggested by Theobald, was tried.

Formula :	Soap	40 lbs.
	Paraffin	8 gallons
	Water	100 gallons.

This spray was applied in the same way and at the same time as the first application of arsenate of lead.

The results obtained are given in Table I., but so severe was the scorching of the leaves in spite of very complete emulsification when mixing the materials,

that only a few examinations were made of fruit, as this treatment appeared too dangerous to be of use.

The figures show a small measure of control which might have been greater had it been possible to give three applications.

In both 1920 and 1921 there appeared to be a decided difference in size and quality between the apparently uninfected berries of the sprayed and unsprayed plots in favour of the sprayed. This was so marked that the different samples for examination could be named without looking at the labels on the baskets. This difference was again apparent this year and appeared to be due to minor damage by the larvæ of the logan beetle and possibly other insects, which had had a stunting effect on the berries. The fruit referred to cannot be definitely classed as infected as it shows none of the usual signs of infection. The difference was more marked in good ripening weather—in wet weather even the best of the normal berries failed to " grow out " to the fullest extent possible, but remained much on a par with the unsprayed. When the same facts were again noted this year it was decided to make counts of the number of berries infected and otherwise in 2 lbs. nett of fruit from each treatment at each picking, and this was commenced with the third picking on July 19th and continued to the end of the season. The figures obtained were as follows :

	Sprayed.	*Unsprayed.*
Average number of berries per 1 lb. nett of fruit ..	125.5	133.3

This equals a saving of 7.8 berries per lb, and 17,472 berries per ton. This at 125.5 berries to the lb. equals an increase of 139 lbs., which at 6d. per lb. would be worth 69s. 6d.

Sixpence per lb. was the average price for the entire crop marketed by the Station this year.

If these figures be applied to a crop of 2½ tons per acre, the increased gross profit equals £8 13s. 9d. This presupposes a similar price for both sprayed and unsprayed fruit, whereas the former when at their best would probably make a slightly better price, especially if the distance to market were considerable.

The cost of spraying must naturally vary with the type of spraying machine used, the proximity of the water supply, freedom from breakdown, etc. With the machine used at the Station, a small power sprayer which can be pulled down the alley ways between the trellises by one horse, it is estimated that the cost per acre per spraying works out as follows :

	£	s.	d.
2 men at 32/– per week of 5½ days, for one day ..		11	8
1 Carter at 36/– per week of 5½ days, for one day ..		6	6½
1 horse at 7/6 per day, for one day		7	6
34 lbs. of Arsenate of Lead at 1/2 per lb.	1	17	4
	£3	3	0½

This estimate would not, of course, hold for all districts, but even if the round sum of £10 10s. per acre for three sprayings be taken as a safe covering figure, the deficit, after substracting £8 15s. 9d., the increased gross profit, is only 36/3 per acre. It should be remembered, however, that the berries in the unsprayed plot were only 9.1 per cent. infected. It appears reasonable to assume that the spraying would have shown a profit last year when the unsprayed averaged 19.8 per cent. infected as opposed to 4.9 per cent. infected in the sprayed, that is assuming that the greater the infection the greater the number of undersized berries.

Unfortunately, figures on the relative weights of the crops under the two treatments were not taken.

Before it can be estimated to what extent the spraying pays for itself in the various years of application, figures will have to be taken for a full series of sprayings, that is from the commencements of dealing with a plot showing a high percentage of infection, to the reduction to some 2 per cent. infected, which is probably the limit of freedom obtainable.

In a case where the infection was so great that the bushes would have to be grubbed if no spraying were undertaken, a certain portion of the value of the trellis work could be placed to the credit of the spraying.

It is hoped that it will be possible to undertake this work on costs which would include a test as to the length of time a plot reduced to 2 per cent. infected can be left without spraying.

Conclusions.

1. Arsenate of Lead appears to control the Logan beetle effectively, if applied when the blossoms are one-third, two-thirds, and fully open.

2. The results warrant the commercial application of the treatment provided a deterrent to bees can be found which will mix with the Arsenate of Lead.

3. The first spraying and possibly the second should pay for themselves in the year of their application. The third spraying will probably show a loss, but it is hoped that it will prove possible to dispense with spraying for two years if the infection, after the third spraying, is only 2 per cent., in which case the complete cycle of operations should show considerable profits.

4. An 8 per cent. Paraffin Emulsion, while showing some measure of control, may cause severe scorching of the foliage and is therefore a dangerous remedy.

BOOK REVIEWS.

FRUIT PACKING FOR MARKET.

The Worshipful Company of Fruiterers have shown their practical interest in promoting the home industry by issuing this little book on Fruit Packing. In it the author—Mr. W. P. Seabrook—has given a clear and accurate account of the methods at present practised ; a description of suitable market packages, together with technical details of the processes of packing. The processes are made easier to understand by the inclusion of photographs and diagrams, which make the book more valuable to beginners.

Mr. Duncombe Gibbs has contributed an interesting story of the Pershore Co-operative Market ; the first of its kind in Great Britain. Mr. W. P. Wright has added a chapter on the Growing of Hardy Fruits for the Market.

The book, written by a practical grower, should be of great use in helping home growers to embrace the modern methods for marketing fruit.

H.V.T.

EDITORIAL NOTE.

A YEAR has passed since the last number of this Journal appeared and we now revive publication under favourable auspices. The transfer of responsibility from private hands should lead to that permanence which is so necessary to make the " Journal of Pomology and Horticultural Science " an epitome of the best work in these subjects. Such transfer, however, does not lessen the need for a wide circle of subscribers ; adequate publication and illustration of results can only thus be obtained. It may be said that the whole of those interested, including contributors, give, as before, their services, and subscriptions are therefore entirely absorbed in the costs of production and distribution.

The circle from which contributions are drawn is naturally limited, but the Publication Committee is anxious to receive papers for consideration from any interested. To be of real value the " Journal " must represent the views of those professionally engaged in horticulture, and the amateur, as well as the contributions of the scientific worker. A healthy critical breeze should blow from one to the other, and the laboratory and library will benefit by such ventilation. The facts observed by the practical grower are of not less value than those discovered by science workers, and both need free discussion and the test of extended experiment before they can be embodied in general practice.

Criticism of theories and facts are a necessary instrument of progress, and in providing a forum for such debates this Journal will fulfil, it is hoped, one of the main objects of its existence.

FIG. 26.

GOVERNOR WOOD

(On left-hand side), 103 flowers self-pollinated, no fruit set. (On right-hand side), 95 flowers crossed Bedford Prolific, 37 fruits set. 85 flowers crossed Belle D'Orleans, 43 fruits set. 88 flowers crossed Black Tartarian, 29 fruits set. 32 flowers crossed Knight's Early Black, 20 fruits set. 17 flowers crossed Wye Morello, 5 fruits set.

REPORT ON TESTS OF SELF-STERILITY AND CROSS-INCOMPATIBILITY IN PLUMS, CHERRIES, AND APPLES AT THE JOHN INNES HORTICULTURAL INSTITUTION. – II

By M. B. CRANE.

(*Technical Assistant, John Innes Horticultural Institution.*)

In a former paper* certain aspects of these experiments, and the results obtained up to the year 1918 were reported upon in detail. The work has been continued in each succeeding year, on trees grown in pots in a specially constructed orchard-house. This house is provided with mosquito bars to exclude insects, and various other precautions are taken to prevent errors occurring. That they provide an efficient control, and reduce disturbances to a minimum, is strikingly evident each season.

The present report relates mainly to work done since the above paper appeared. It was, however, evident that a repetition of certain selfs and crosses would be of value, and as this has been done it will be necessary to refer briefly to some of the earlier work.

In the work of emasculation and pollination many workers at this Institution have taken part, and among others who have assisted in recent years must be mentioned Mr. R. J. Chittenden, and Mr. H. C. Pugsley.

Prior to self-sterility being established, and in all crosses where the variety used as female has proved to be in any degree self-fertile, the flowers were emasculated. Later, in those varieties which repeatedly failed with their own pollen the anthers were not always removed.

The trees, with very few exceptions, were in the finest condition throughout the experiments. With work of this kind the measure of fertility must be the proportion of fruits which actually reach maturity. The health of the trees is therefore obviously of the greatest importance; otherwise the observations would be altogether unreliable.

CHERRIES.

All the sweet Cherries—the Bigarreaus and the Guignes, *Prunus avium*—that have been tested were found to be self-sterile. On two varieties a single fruit set out of a large number of flowers pollinated. At present I am inclined to regard these as attributable to error; it may, however, mean that self-compatibility exists in a very slight degree.

* Sutton I. *Journal of Genetics*, Vol. VII, No. 4, pp. 281-300, 1918. This report also appeared in *Journal of Pomology*, Vol. I, pp. 1-19.

The sour Cherries *Prunus cerasus*, and the Dukes, have been less extensively dealt with, but among them varying degrees of self-fertility occur.

Crosses between these groups have varied in their ability to form fruits, and from reciprocal crosses there is evidence of compatibility being greater when the crosses are made one way, than the other. Sweet varieties as females, fertilised by Duke's and sour varieties as males, generally produce and mature fruits freely, but from reciprocal crosses fruits are less freely formed. The total results of such crosses are :—

♀	♂		♀		♂
Bigarreaus and Guignes	Morellos Kentish and Dukes	×	Morellos Kentish and Dukes	×	Bigarreaus and Guignes.
Flowers 1121			Flowers 866		
Fruits 324 or 28.9 per cent.			Fruits 76=8.7. per cent.		

Cross-incompatibility.

Among the varieties of the sweet Cherry three groups of incompatibles have been met with. So far nine varieties are involved ; they are :—

Group I.	Group II.	Group III.
Early Rivers	Big. de Schrecken	Big. Napoleon
Bedford Prolific	Big. Frogmore	Emperor Francis
Black Tartarian		
Black Tartarian "A"		
Knight's Early Black		

Reference to the tables shows that with very rare exceptions crosses made within these groups gave no fruit. The details given more precisely in the tables at the end of this paper are summarised in the following diagram.

From 1187 flowers of Big. de Schrecken pollinated by Big. Frogmore one fruit formed, a few fruits have also resulted from the reciprocal cross out of a large number of flowers pollinated. These fruits all occurred in one year ; conceivably they may be the result of some error, for in a previous year these combinations gave wholly negative results, and in subsequent years extensive repetition on the same and also on other trees of these varieties completely failed.

All the other crosses so far attempted within the groups, have wholly failed. The number of flowers used in most of the self, and in many of the cross-combinations is large. Usually two trees of each variety have been used and the crosses repeated in successive years. In some cases, however, the number of flowers crossed is small, and further work and confirmation is necessary before they can be regarded as conclusively proved, but the facts highly suggest that complete incompatibility will be found to exist within these groups.

♀ \ ♂	Early Rivers	Bedford Prolific	Knight's Early Black	Black Tartarian	Black Tartarian "A"	Bigarreau de Schrecken	Big. Frogmore Early	Emperor Francis	Big. Napoleon
Early Rivers	234 0	95 0	100 0	481 0	178 0	94 13	47 2		
Bedford Prolific	40 0	230 0	85 0	13 0	34 0	31 16	30 29		
Knight's Early Black		282 0	573 1	141 0	32 0	100 27	34 6		110 26
Black Tartarian	373 0	75 0		90+ 0	40 0				80 13
Black Tartarian "A"	108 0	20 0		42 0	210 0	33 4	13 2		
Big. de Schrecken	101 49	67 7	195 59			364 0	1187 1		
Big. Frogmore Early	105 18	70 19				580 6	550 0		
Emperor Francis		99 30		20 11		47 21	128 54	260 0	
Big. Napoleon								33 0	65 1

Diagram showing the self and cross combinations made between incompatible varieties of cherries. The numbers at the top of the squares are the number of flowers pollinated, those at the bottom are the number of fruits which set and matured. The double squares are incompatible combinations.

The parentage of the majority of these incompatibles is not known on either side. In regard to varieties in Group I, however, the following is of interest. The female parent of Early Rivers is Early Purple Gean; Bedford Prolific is a seedling from Black Tartarian, whilst the origin of Knight's Early Black is Bigarreau × May Duke. From this it is evident that some may be related, e.g., Black Tartarian and Bedford Prolific, whilst the immediate parents of Knight's Early Black indicate that others may be of a distinct origin.

Most of the crosses attempted between the groups have resulted in full crops of fruit; the behaviour of Early Rivers (group 1) when pollinated with Big. Frogmore (Group 2) is, however, of interest. This cross has been attempted on a small scale on two occasions, first sixteen flowers were crossed and two fruits

were formed, but both contained only partly formed seeds which proved to be non-viable. When repeated thirty-one flowers were crossed, sixteen of these formed fruits which reached a very advanced stage before they stopped developing and fell. They also contained very imperfect seeds in which but little embryonic tissue had formed.

In the Cherry—as in the Plum—there is a primary development which doubtless is wholly maternal; with both self-fertile and self-sterile varieties, whether the flowers have been crossed with compatible varieties, selfed, or not pollinated at all, the development of the fruit is approximately the same during the first three or four weeks. After this period the effective selfs and compatible crosses continue to develop, but the unpollinated and incompatible selfs and crosses begin to shrivel and soon fall.

In the plum, Mr. E. J. Collins has made investigations on this subject, and has found that in the incompatible combinations and also in self-sterile varieties, the plant's own pollen germinates and penetrates the nutrient stylar tissue, but the tubes fail to travel the full length of the style and do not reach the ovary. A similar phenomen has been seen by previous observers in other self-sterile plants. It is therefore clear that in these cases fertilisation does not occur, and that growth is arrested, the young fruits subsequently falling for this reason.

The fruits of the whole of the crosses made within the incompatible groups of Cherries fall early in their development, i.e., at a stage corresponding with the fall attributable to non-fertilisation. When Early Rivers is crossed by Big. Frogmore, however, incompatibility is not expressed until a much later stage; apparently not until long after fertilisation occurred. For some reason, however, embryonic growth is arrested and the fruits shrivel and fall.

Our records of the breeding work show that it is not uncommon for Cherries to reach maturity and contain only imperfect and non-viable seeds. The degrees of failure after pollination may be roughly classified, and they are fairly definite :—

(1) Fruits falling very early as if unfertilised.

(2) Fruits falling much later, in which embryonic growth has begun, but ceases at about half size.

(3) Fruits reaching maturity, but containing imperfect seeds: the arrest of embryonic development being postponed to a later stage than those reached by (2).

Examples of cross-incompatibility in the sweet Cherry, among varieties commonly grown in America have previously been reported upon by Gardner.* Gardner also found all the varieties he used to be self-sterile.

* Gardner, V. R. A Preliminary Report on the Pollination of the Sweet Cherry. Bull. No. 116. *Oregon Agric. Coll. Exp. Stn.* 1913.

Owing to the confusion which prevails in the nomenclature of Cherries, the identification of some varieties is uncertain. The varieties in the groups previously referred to are all distinct individuals, and with the exception of Black Tartarian and one that I have called Black Tartarian " A," it is believed that they are correctly named. Regarding the identity of Black Tartarian there appears to be no general agreement. Lindley, in the *Pomologia Britannica* (1841) describes and figures Black Tartarian. It has large imbricate flowers and other characteristics with which our Black Tartarian agrees. Black Tartarian " A " however, has small stellate flowers, and other distinct differences. So far we have not been able to identify this variety, but from our experience it appears to be commonly distributed under the name of Black Tartarian.*

Other difficulties have occurred, and it is necessary to call attention to two of these, i.e., Morello and Kentish Red. The Morello which appears in the appended records is less self-fertile and quite distinct from the Morello used and recorded in our 1918 report. The true Kentish Red, as far as I can determine, is the individual which has proved self-sterile in our experiments. Kentish Red " A " as the appended records show is self-fertile. It is quite distinct from the true Kentish, and also from Flemish Red with which Kentish is sometimes confused.

I am indebted to Mr. E. A. Bunyard for kind assistance and references regarding the identity of several varieties of Cherries, and also to Mr. C. H. Hooper for the tree of Wye Morello used in these experiments.

APPLES.

SOME of our earlier results, the records of which appeared in our last report, suggested the view that compatibility existed in a higher degree between certain varieties than others. Repetition and further work, however, are as a whole against such a view. For example, when Cox's Orange Pippin was crossed with Sturmer Pippin and Newton Wonder, but few fruits set. When repeated, these and other similar cases have resulted in full crops of fruit. So far, we have not observed any clear example of either complete or partial cross-incompatibility in Apples.

These experiments have now been in progress for twelve years ; trees of many varieties have been successively used during this time, and in some varieties it is evident that the degree of self-fertility has increased with advancing age. Several varieties which for a number of years had given wholly negative results have later formed occasional fruits with their own pollen.

* This season (1923) a third Black Tartarian has been introduced into the experiments. It is quite distinct from the others previously obtained under this name, and I believe some authorities regard it as the Black Tartarian of Lindley. From experiments recently made there are indications that this individual is compatible with the varieties in Group (1), though as yet I cannot be certain of this.

In 1912, six trees of Cox's Orange Pippin of equal age and size were brought into the experiments; they flowered freely from 1914 onwards and large numbers of flowers have been self-pollinated in most seasons. In 1918, for the first time, two fruits set out of 816 flowers that were self-pollinated; since then these trees have always formed occasional fruits whenever they have been selfed. Prior to 1918 these and trees of other varieties which have behaved similarly had produced full crops of fruit when they had been crossed.

That varying degrees of self-fertility exists in Apples is evident, but to measure and to express this, and also the results obtained from crossing is extremely difficult. Generally only a small proportion of flowers can succeed in forming fruits, and when trees have flowered very freely, a four per cent. set has frequently given a full crop. Taking two trees equal in size and age, one may flower twice as freely as the other, but owing to the limited number of fruits that the trees are able to carry, approximately the same number of fruits may reach maturity on both. Indeed, when observing comparable examples it is not uncommon for the trees with the fewer flowers to mature the larger number of fruits; often this would be expected. Many other irregularities have to be considered, the details of which could only be recorded at great length, but it is obvious even when many allowances are made, that the percentage set can only be taken as an approximate guide.

The majority of the varieties that we have dealt with, although varying in degree, have proved to be only partially self-fertile. Among those so classified in the appended lists, great variation occurs; some set very few fruits when selfed, whilst others set a moderately good crop. Provision for cross-pollination is however advisable in practice for all varieties in this group.

Stirling Castle and Rev. W. Wilks have set enormous crops with their own pollen; Bramley's Seedling has also set full crops.

In many of the fruits arising from selfing Golden Spire, there was no sign of a seed. Flowers of this variety emasculated and left unpollinated, have also formed seedless fruits, showing that the development of such fruits is wholly maternal. Brownlees Russet is the only variety that has given wholly negative results when selfed; it has not, however, been extensively dealt with. Royal Jubilee has been repeatedly selfed and has formed only one fruit; this was seedless.

Generally, apples arising from self-pollination have contained fewer perfect seeds than fruits which have been crossed. Exceptions, however, have occurred in which crossed fruits have contained but few developed seeds; this may possibly be an indication of compatibility being incomplete.

In some varieties of Apples, the shape of the fruit is influenced by the number of seeds developed, and occasionally fruits without seeds are smaller than those with seeds. Seedlessness, however, does not necessarily involve any diminution

in size. No differences in fruit colour or flavour have been observed that could be attributed to cross-pollination.

In a recent paper*, Rawes has reported upon a large number of varieties of Apples, some of which we have similarly dealt with. Comparing results no wide differences are evident, although there is not always strict agreement. For example, Cox's Orange in Rawes' list stands as a self-sterile, but as occasional fruits which have amounted to three per cent. have set here as a result of self-pollination, I now include it among the partially self-fertiles. Other minor differences occur and are almost to be expected in work of this kind.

Five varieties which appeared as self-steriles in our 1918 report have later set occasional fruits with their own pollen, consequently with further experience I have made some slight modification of the lists previously published.

PLUMS.

Several self-sterile varieties have been repeatedly selfed on a large scale ; they have continued to give wholly negative results. A number of crosses have been made between Plums (*Prunus domestica*), and Damsons and Bullaces (*Prunus insititia*) ; all have resulted in full crops of fruit, indicating that between them complete compatibility exists.

The incompatible Plums previously reported upon have been further dealt with, and the total results are shown in the following diagram. That Late Orange and President are an incompatible pair was originally reported by Rawes.† The crosses that have been made between them and the Coe's and Jefferson have set fruit freely, showing that their incompatibility is of a different kind ; as :—

Group I.	Group II.
Coe's Golden Drop Coe's Violet Crimson Drop	Late Orange President
Jefferson	

Golden Drop, Coe's Violet and Crimson Drop are identical in all respects except fruit colour. The latter two are known to have originated as bud sports from Golden Drop, and I have observed here all three on one tree. Jefferson, however, widely differs from the Coe's in many characters, and the previous suggestion that Jefferson may be a co-derivative of the Coe's is very improbable.

As the records show, occasional fruits have formed when the Coe's have been crossed with Jefferson. Some of these fruits have occurred under very stringent

* Rawes, A. N. " Pollination in Orchards " (V), *Jour. R. H. S.*, Vol. XLVII, pp. 8-14.

† Rawes, A. N. " Pollination in Orchards " (IV), *Jour. R. H. S.*, Vol. XLVI, p. 355.

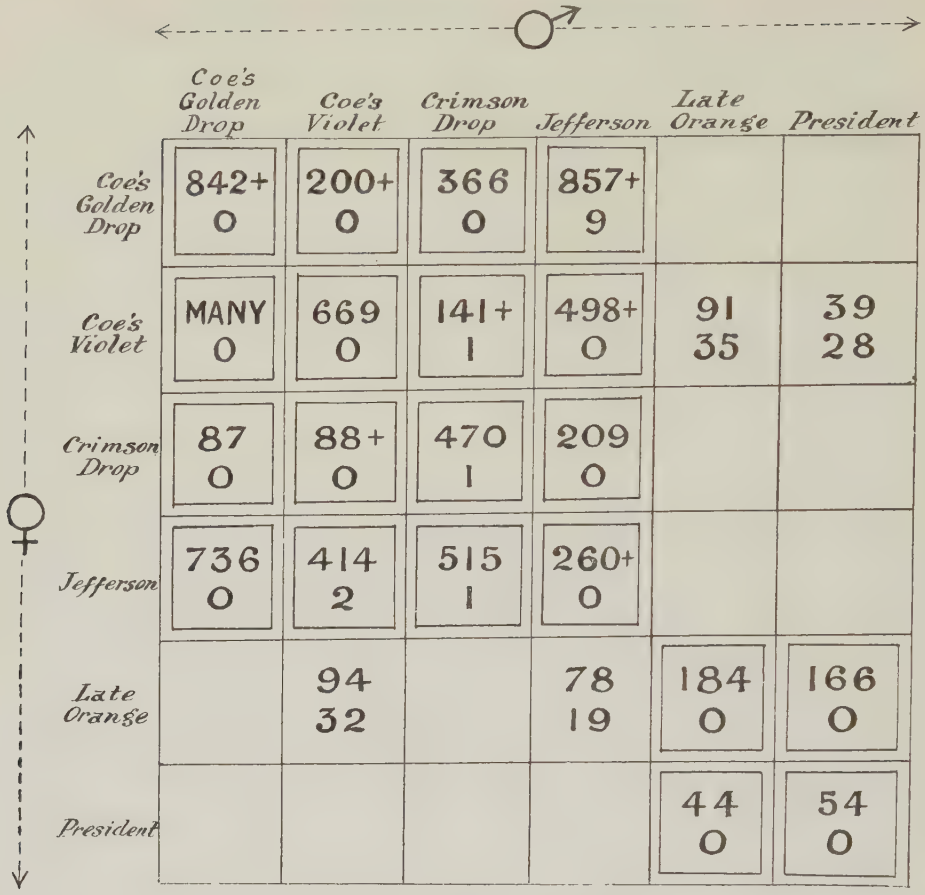

Diagram showing self and cross combinations made between incompatible Plums. The numbers at the top of the squares are the number of flowers pollinated, those at the bottom are the number of fruits which set and reached maturity. + means, that in addition to the number recorded, many more flowers were pollinated, but the actual number was not recorded.

conditions, and I am led to believe, that as a rarity a pollen grain occurs in these combinations which has the ability to travel the full length of the style and effect fertilisation.

The number of cross-combinations that have been made here and by other workers is now large, but the above are the only examples of cross-incompatibility so far reported. It is indeed remarkable, since cross-incompatibility has been found to exist in Plums that so few cases have been met with.

A number of seedlings obtained from selfing self-fertile varieties have been selfed, and all proved to be self-fertile, at least in some degree. This may ultimately be significant, but at the present stage of this part of the work we

have no real evidence regarding the heredity of self-sterility in the Plum, and the records are for the present withheld.

Failure of Flowers to Develop.

A number of flowers often occur on fruit trees which are obviously not destined to form fruits. Such flowers consist of some which are morphologically abnormal, and others, which though normal in structure fall soon after opening, and are characterised by the pedicels quickly turning yellow. This fall occurs earlier than the fall attributable to non-fertilisation. In regard to these experiments, however, this fall need not be considered here, as it has involved but a small percentage of the flowers, and in all cases many more fully normal flowers have developed than could possibly be expected to form fruits.

Conclusions.

From the horticultural point of view the conclusions to be drawn from these experiments are :—

1. That many varieties of fruit trees are completely self-sterile and wholly fail to set fruit with their own pollen.

2. Many, although not completely self-sterile, are incapable of producing a satisfactory crop with their own pollen.

3. In the sweet Cherry, and in the Plum, cross-incompatibility occurs, i.e., some varieties when pollinated with the pollen of certain other varieties wholly fail to form fruits.

4. That to obtain good crops from these kinds, provision for cross-pollination is necessary, and for the incompatible Cherries and Plums it is important that the right varieties are provided for this purpose.

5. It is important that varieties which flower at the same time be planted together, but for efficient pollination there is nothing which necessitates the planting of varieties which are of but little commercial value, neither is it necessary to plant a large number of varieties, or to interplant in such a way that practical cultural operations are seriously interfered with.

Some varieties of fruit trees produce pollen more freely than others, and in this way they may possibly be better pollinisers. Observations, however, made on cultures of the pollen of a large number of varieties show that the amount of pollen which is obviously bad varies, but in no variety has the proportion aborted been sufficiently large to indicate that it would greatly effect its value as a polliniser, nor in the practical work of crossing has such a case been met with.

In a study of sterility in the Plum, Dorsey* working in America, has reported cases where a very high per cent. of aborted pollen occurs. They were

* Dorsey, M. J. A Study of Sterility in the Plum. *Genetics*, Vol. IV, pp. 417-488, 1919.

not, however, varieties of *domestica* and *insititia* with which we are here concerned, but derivatives from other species and various hybrid forms.

CHERRIES.

Self-Sterile.
Amber Heart (Kentish Big.)
Bedford Prolific.
Black Eagle.
Black Heart.
Black Tartarian.
Black Tartarian " A."
Bigarreau de Schrecken.
Bigarreau Frogmore.
Bigarreau Jaboulay.
Bigarreau Late Black.
Bigarreau Noir de Guben.
Bigarreau Noir de Schmidt.
Bigarreau Napoleon.
Belle D'Orleans.
Early Rivers.
Elton.
Emperor Francis.
Governor Wood.
Guigne D'Annonay.
Knight's Early Black.
Noble.
Turkey Heart.
Waterloo.
Kentish Red.

Partially Self-Fertile.
May Duke.
Royal Duke.

Self-Fertile.
Kentish Red " A."
Late Duke.
Morello.
Wye Morello.

APPLES.

Self-Sterile.
Brownlees' Russet.
Royal Jubilee.

Partially Self-Sterile.
Beauty of Bath.
Bismarck.
Blue Pearmain.
Cox's Orange Pippin.
Duke of Devonshire.
Encore.
Golden Russet } *
St. Edmund's Russet. }
Grenadier.
King's Acre Pippin.
Lady Sudeley.
Lane's Prince Albert.
Lord Grosvenor.
Newton Wonder.
Nonsuch Paradise.
Norfolk Beauty.
Northern Greening.
Sturmer Pippin.
Winter Ribston (Orleans Reinette).
Worcester Pearmain.

Self-Fertile or Self-Fruitful.†
Antonowka.
Bramley's Seedling.
Crimson Bramley.
Doucin.
French Paradise.
Golden Spire.
Lord Derby.
Rev. W. Wilks.
St. Everard.
Stirling Castle.

PLUMS.

Self-Sterile.
Bryanstone Gage.
Cambridge Gage.
Coe's Golden Drop.
Coe's Violet.
Crimson Drop.
Jefferson.
Kirke's Blue.
Late Orange.
Late Orleans.
McLaughlin's Gage.
Old Greengage.
Pond's Seedling.
President.
Prune d'Agen.
Transparent Gage.
Yellow Magnum Bonum.

Partially Self-Fertile.
Belgian Purple.
Cox's Emperor.
Early Orleans.
Rivers' Early Prolific.
Frogmore Damson.

Self-Fertile.
Early Transparent.
Gisborne's.
Goliath.
Guthrie's Late.
Pershore.
Prince of Wales.
Victoria.
White Magnum Bonum.‡
Farleigh Damson.
King of the Damsons.

* The two Russets used here were the same; presumably St. Edmund's Russet.

† Some of the following set very heavy crops indeed, and all satisfactory crops with their own pollen. With some, however, a heavier crop is obtained from cross-pollination.

‡ White Magnum Bonum appeared as Yellow Magnum Bonum in our last report. I believe they are frequently regarded as synonymous, but we have since met with a variety distributed as Yellow Magnum Bonum which is self-sterile and it also differs in other characters.

CHERRIES.

Selfed.				Crossed.			
	Flowers.	Fruit.	% set.	Pollinated by	Flowers.	Fruit.	% set.
Amber Heart (Big Kentish)	96	0	—	Guigne D'Annonay ..	66	25	37.8
„ „ ..	36	0	—	„ „ ..	141	29	20.5
„ „ ..	138	0	—	Big. Noir de Guben ..	25	8	32.0
„ „ ..	102	0	—	Big. Frogmore ..	126	5	3.9
				Wye Morello ..	61	9	14.7
Bedford Prolific ..	44	0	—	Knight's Early Black	14	0	—
„ „ ..	65	0	—	„ „ „	71	0	—
„ „ ..	107	0	—	Early Rivers ..	40	0	—
„ „ ..	14	0	—	Black Tartarian ..	13	0	—
				Black Tartarian "A"	34	0	—
				Big. de Schrecken ..	31	16	51.6
				Big. Frogmore ..	30	29	96.6
				Bohemian Black ..	7	5	71.4
Black Eagle ..	200	0	—	May Duke	69	8	11.5
				Morello	50	13	26.0
				Amber Heart ..	23	20	86.9
Black Heart ..	82	0	—	Big. Frogmore ..	108	41	37.9
„ „ ..	12	0	—	Big. de Schrecken ..	69	17	24.6
				Elton	20	2	10.0
				„	12	5	41.6
				Early Rivers ..	131	19	14.5
				Morello	62	7	11.2
Black Tartarian ..	90	0	—	Early Rivers ..	123	0	—
				„ „ ..	120	0	—
				„ „ ..	130	0	—
				Bedford Prolific ..	75	0	—
				Black Tartarian "A"	40	0	—
				Big. Napoleon ..	80	13	16.2
				Big. Noir de Guben ..	58	20	34.4
				Elton	102	23	22.5
Black Tartarian "A"	99	0	—	Early Rivers ..	37	0	—
„ „ ..	76	0	—	„ „ ..	71	0	—
„ „ ..	35	0	—	Black Tartarian ..	42	0	—
				Bedford Prolific ..	20	0	—
				Big. de Schrecken ..	33	4	12.1
				Big. Frogmore ..	13	2	15.3
				Noble	17	4	23.5
Big. de Schrecken ..	140	0	—	Big. Frogmore ..	269	0	—
„ „ ..	112	0	—	„ „ ..	122	1	.08
„ „ ..	81	0	—	„ „ ..	424	0	—
„ „ ..	31	0	—	„ „ ..	191	0	—
				„ „ ..	181	0	—
				Black Heart ..	109	46	42.2
				Governor Wood ..	198	47	23.7
				Early Rivers ..	74	8	10.8
				„ „ ..	101	49	48.5
				Knight's Early Black	195	59	30.2
				Big. Jaboulay ..	29	5	17.2
				Bedford Prolific ..	67	7	10.4
				Belle D'Orleans ..	106	19	17.9

	Selfed.				Crossed.			
	Flowers.	Fruit.	%set.	Pollinated by	Flowers.	Fruit.	%set.
Big. Frogmore	.. 156	0	—	Big. de Schrecken	.. 63	0	—
,, ,,	.. 81	0	—	,, ,,	.. 170	6	3.5
,, ,,	.. 110	0	—	,, ,,	.. 270	0	—
,, ,,	.. 203	0	—	,, ,,	.. 55	0	—
				,, ,,	.. 20	0	—
				Belle D'Orleans	.. 78	21	26.9
				Bedford Prolific	.. 70	19	27.1
				Black Heart ..	.. 145	18	12.4
				Elton ..	.. 52	4	7.6
				Big. Kentish ..	.. 148	53	35.8
				Noble ..	.. 52	20	38.4
				Early Rivers ..	.. 42	6	14.2
				,, ..	.. 63	12	19.0
				Wye Morello ..	.. 20	7	35.0
Big. Jaboulay	.. 98	0	—	Big. Frogmore	.. 24	18	75.0
,, ,,	.. 41	0	—	Big. de Schrecken	.. 87	39	44.8
				Black Tartarian	.. 18	13	72.2
				Bedford Prolific	.. 58	32	55.1
				Kentish Red	.. 16	8	50.0
Big. Late Black	.. 101	0	—	Big. Noir de Schmidt	46	19	41.3
				Big. Frogmore	.. 8	4	50.0
Big. Noir de Guben	89	0	—	Early Rivers	.. 160	98	61.2
,, ,,	.. 87	0	—	Governor Wood	.. 63	31	49.2
				Morello ..	.. 63	21	33.3
Big. Noir de Schmidt	302	0	—	Big. Frogmore	.. 20	14	70.0
				Big. Late Black	.. 90	47	52.2
Big. Napoleon	.. 65	1	1.5	Guigne D'Annonay	86	26	30.2
				,, ,,	.. 71	36	50.7
				Big. Kentish	.. 32	14	43.7
				Kentish Red	.. 20	11	55.0
				Emperor Francis	.. 33	0	—
Belle D'Orleans	.. 106	0	—	Big Napoleon	.. 28	9	32.1
Early Rivers	.. 136	0	—	Black Tartarian	.. 170	0	—
,, ,,	.. 57	0	—	,, ,,	.. 152	0	—
,, ,,	.. 41	0	—	,, ,,	.. 159	0	—
				Black Tartarian "A"	26	0	—
				,, ,, "A"	90	0	—
				,, ,, "A"	62	0	—
				Bedford Prolific	.. 95	0	—
				Big. Frogmore	.. 16	2	12.5
				,, ,,	.. 31	0	—
				Big. de Schrecken	.. 94	13	13.8
				Governor Wood	.. 145	33	27.7
				Knight's Early Black	100	0	—
Elton ..	.. 78	0	—	Black Heart	.. 141	23	16.3
				,, ,,	.. 123	46	37.3
				Early Rivers	.. 106	9	8.4
				Big. Frogmore	.. 63	19	30.1
				Big. Jaboulay	.. 71	21	29.5
				Morello ..	.. 115	35	30.4

	Selfed.				Crossed.		
	Flowers.	Fruit.	%set.	Pollinated by	Flowers.	Fruit.	%set.
Emperor Francis	.. 93	0	—	Turkey Heart	.. 40	24	60.0
„ „	.. 167	0	—	Bedford Prolific	.. 99	30	30.3
				Big. de Schrecken	.. 47	21	44.6
				Big. Frogmore	.. 128	54	42.1
				Black Tartarian	.. 20	11	55.0
Governor Wood	.. 101	0	—	Big. Napoleon	.. 70	29	41.4
„ „	.. 112	0	—	Early Rivers	.. 121	39	32.2
„ „	.. 103	0	—	Big. Noir de Guben	.. 120	45	37.5
				Bedford Prolific	.. 95	37	38.9
				Belle D'Orleans	.. 85	43	50.5
				Black Tartarian	.. 88	29	32.9
				Knight's Early Black	32	20	62.5
				Wye Morello	.. 17	5	29.4
Guigne D'Annonay	.. 183	0	—	Early Rivers	.. 186	68	36.5
				Big. de Schrecken	.. 186	54	29.0
				Royal Duke	.. 71	13	18.3
				Kentish Red	.. 63	13	20.6
Knight's Early Black	340	0	—	Bedford Prolific	.. 90	0	—
„ „	.. 77	0	—	„ „	.. 192	0	—
„ „	.. 156	1	0.6	Black Tartarian	.. 141	0	—
				Black Tartarian "A"	32	0	—
				Big. Napoleon	.. 36	3	8.3
				„ „	.. 74	23	31.0
				Big. Frogmore	.. 34	6	17.6
				Morello ..	.. 25	9	36.0
				Kentish Red "A"	.. 23	3	13.0
				Big. de Schrecken	.. 100	27	27.0
Noble ..	.. 109	0	—	Big. Frogmore	.. 54	21	38.8
„ ..	.. 90	0	—	„ „	.. 60	18	30.0
				Kentish Red	.. 18	4	22.2
				Wye Morello	.. 26	2	7.6
Turkey Heart	.. 116	0	—	Waterloo ..	.. 38	6	15.7
„ „	.. 151	0	—	Emperor Francis	.. 76	22	28.9
Waterloo ..	.. 90	0	—	Amber Heart	.. 215	80	37.2
				Morello ..	.. 203	62	30.5
				May Duke ..	.. 199	94	47.2
Kentish Red	.. 406	0	—	Morello ..	.. 146	15	10.2
„ „	..2488	0	—	May Duke ..	.. 55	2	3.6
				Governor Wood	.. 60	3	5.0
Kentish Red "A"	.. 206	69	33.4	Morello ..	.. 57	16	28.0
„ „	.. 100	23	23.0	Big. Frogmore	.. 23	8	34.7
Morello ..	.. 470	6	1.2	May Duke ..	.. 43	4	9.3
„ ..	.. 434	34	7.8	Amber Heart	.. 62	1	1.6
„ ..	.. 303	57	18.8	Turkey Heart	.. 43	1	2.3
				Big. Noir de Guben	.. 137	18	13.1

	Selfed.				Crossed.		
	Flowers.	Fruit.	%set.	Pollinated by	Flowers.	Fruit.	%set.
Wye Morello	.. 360	52	14.4	Big. Frogmore	.. 44	7	15.9
				Big. Late Black	.. 40	6	15.0
				Big. Napoleon	.. 34	1	2.9
Late Duke ..	..1542	159	10.3	May Duke ..	.. 55	19	34.5
				Kentish Red	.. 61	14	22.9
				Big. Frogmore	.. 53	8	15.0
				Governor Wood	.. 102	10	9.8
May Duke ..	.. 417	5	1.1	Late Duke ..	.. 7	3	42.8
,, ,, ..	.. 443	8	1.8	Kentish Red	.. 24	3	12.5
				Morello ..	.. 79	8	10.1
				Big. Napoleon	.. 37	3	8.1
				Amber Heart	.. 23	1	4.3
				Black Eagle	.. 42	6	14.2
				Waterloo ..	.. 26	2	7.6
Royal Duke	.. 127	3	2.3	Big. de Schrecken	.. 45	1	2.2
,, ,, ..	.. 300	7	2.3	Bedford Prolific	.. 35	0	
				Big. Frogmore	.. 20	0	—
				Early Rivers	.. 40	0	—
				Wye Morello ..	.. 48	3	6.2

PLUMS.

Belgian Purple	.. 307	23	7.4	Coe's Violet	.. 11	7	63.6
,, ,,	.. 148	8	5.4				
Bryanstone Gage	.. 105	0	—	Jefferson ..	.. 415	339	81.6
Cambridge Gage	.. 100	0	—	Rivers' Early Prolific	15	10	66.6
Coe's Golden Drop	.. 724	0	—	Prune Géante	.. 284	38	13.3
,, ,,	.. 23	0	—	Early Orleans	.. 222	30	13.5
,, ,,	.. 95	0					
Coe's Violet	.. 240	0	—	Jefferson ..	.. 190	0	—
,, ,, ..	.. 158	0	—	,, ..	.. 37	0	—
,, ,, ..	.. 68	0	—	Kirke's Blue ..	.. 58	17	29.3
				Pershore ..	.. 140	27	19.2
				Late Orange ..	.. 91	35	38.4
				President ..	.. 39	28	71.7
				Victoria ..	.. 65	42	64.6
				Cox's Emperor	.. 189	49	25.9
				Frogmore Damson	.. 270	41	15.1
Cox's Emperor	.. 115	0	—	McLaughlin's Gage	398	55	13.8
,, ,,	.. 132	2	1.5	Pond's Seedling	.. 562	75	13.3
				Frogmore Damson	.. 341	31	9.0
Crimson Drop	.. 143	0	—	Jefferson ..	.. 77	0	—
,, ,,	.. 33	0	—	Old Greengage	.. 232	73	31.4
				Kirke's Blue ..	.. 240	51	21.2
				Black Bullace	.. 89	13	14.6

	Selfed.				Crossed.		
	Flowers.	Fruit.	%set.	Pollinated by	Flowers.	Fruit.	%set.
Early Orleans	795	13	1.6	Prune Géante	242	27	11.1
Early Transparent	66	14	21.2	Pond's Seedling	27	4	14.8
,, ,,	216	131	60.6				
Gisborne's	300	48	16.0				
Goliath	211	82	38.8	Yellow Magnum Bonum	66	6	9.0
,,	135	46	34.0				
Guthrie's Late	75	19	25.3	Coe's Violet	14	4	28.5
Jefferson	22	0	—	Crimson Drop	106	1	0.9
,,	69	0	—	McLaughlin's Gage	38	28	73.6
,,	55	0	—	Late Orleans	162	43	26.5
				Bryanstone Gage	40	27	67.5
				Old Greengage	72	38	52.7
				McLaughlin's Gage	64	26	40.6
				Cox's Emperor	59	45	76.2
				Black Bullace	24	4	16.6
				Prunus spinosa	50	0	—
Kirke's Blue	360	0	—	Old Greengage	327	63	19.2
,, ,,	104	0	—	Coe's Violet	108	25	23.1
Late Orange	184	0	—	President	61	0	—
				,,	105	0	—
				Jefferson	78	19	24.3
				Coe's Violet	94	32	34.0
				Farleigh Damson	15	6	40.0
Late Orleans	579	0	—	Late Orange	49	12	24.4
,, ,,	260	0	—	Rivers' Early Prolific	163	34	20.8
,, ,,	250	0	—	Bryanstone Gage	47	18	38.2
,, ,,	271	0	—	Mc'Laughlin's Gage	92	13	14.1
,, ,,	548	0	—	King of the Damsons	165	50	30.3
				Farleigh Damson	73	22	30.1
				White Damson	61	15	24.5
				Prune Géante	252	38	15.0
				,, ,,	196	23	11.7
				Early Orleans	196	58	29.5
McLaughlin's Gage	30	0	—	Cox's Emperor	112	29	25.8
,, ,,	100	0	—	Jefferson	43	24	55.8
,, ,,	72	0	—	Coe's Violet	31	18	58.0
,, ,,	29	0	—	Goliath	36	24	66.6
				Pond's Seedling	211	58	27.4
				Black Bullace	38	28	73.6
Old Greengage	187	0	—	Jefferson	562	68	12.0
,, ,,	199	0	—	Kirke's Blue	243	30	12.3
				Crimson Drop	444	64	14.4
				McLaughlin's Gage	217	21	9.6

	Selfed.				Crossed.			
	Flowers.	Fruit.	%set.	Pollinated by	Flowers.	Fruit.	%set.
Pershore	32	13	40.6	Victoria	136	63	46.3
Pond's Seedling ..	44	0	—	Cox's Emperor ..	283	48	16.9
„ „ ..	178	0	—	Rivers' Early Prolific	48	23	47.9
„ „ ..	88	0	—	Yellow Magnum Bonum	60	37	61.6
„ „ ..	26	0	—	Early Transparent ..	23	7	30.4
				Transparent Gage ..	76	38	50.0
				McLaughlin's Gage ..	221	43	19.4
				Farleigh Damson ..	18	8	44.4
President	54	0	—	Late Orange ..	44	0	—
				Rivers' Early Prolific	18	11	61.1
Prince of Wales ..	279	46	16.4				
„ „ ..	79	42	53.1				
Prune d'Agen ..	250	0	—	Coe's Golden Drop ..	200	48	24.0
„ „ ..	75	0	—	Prune Géante ..	198	31	15.6
Rivers' Early Prolific	103	8	7.7	Pond's Seedling ..	85	19	22.3
„ „	284	2	0.7	Yellow Magnum Bonum	86	20	23.2
„ „	529	11	2.0	Early Transparent ..	96	16	16.6
				Late Orange ..	102	38	37.2
				President	48	13	27.0
				Victoria	50	19	38.0
Transparent Gage ..	263	0	—	McLaughlin's Gage ..	44	16	36.3
„ „ ..	290	0	—				
Victoria	45	14	31.1	Pershore	120	29	24.1
„	70	45	64.2	Farleigh Damson ..	15	8	53.3
				King of the Damson's	20	10	50.0
				White Damson ..	17	12	70.5
				Prunus spinosa ..	17	0	—
White Magnum Bonum	44	24	54.5	Late Orleans ..	27	9	33.3
Yellow Magnum Bonum	54	0	—	Late Orleans ..	15	3	20.0
				White Magnum Bonum	24	8	33.3

DAMSONS.

Farleigh Damson ..	334	4	1.1	Pond's Seedling ..	70	34	48.5
„ „ ..	238	53	22.2	President	99	50	50.5
				Early Transparent ..	72	27	37.5
				Late Orleans ..	62	22	35.4
King of the Damsons	36	20	55.5	Coe's Violet	14	10	71.4
„ „ ..	210	90	42.8	*Prunus spinosa* ..	25	4	16.0
Frogmore Damson ..	1293	2	0.1	Coe's Golden Drop ..	608	114	18.7
				Cox's Emperor ..	723	103	14.2
				Pond's Seedling ..	462	80	17.3

APPLES

	Selfed.				Crossed.			
	Flowers.	Fruit.	%set.	Pollinated by	Flowers.	Fruit.	%set.
Antonowka	48	2*	4.1				
„	90	5*	5.5				
Beauty of Bath	70	0	—	Norfolk Beauty	106	12	11.3
„ „	1146	13	1.1	Rev. W. Wilks	75	9	12.0
„ „	527	17	3.2	Golden Spire	157	11	7.0
				Bramley's Seedling	129	6	4.6
Bismarck	180	5	2.7				
Blue Pearmain	200	0	—				
„ „	236	3	1.2				
Bramley's Seedling	260	32	12.3	Beauty of Bath	74	2	2.7
Brownlees Russet	220	0	—				
„ „	294	0	—				
Cox's Orange Pippin	339	0	—	Crimson Bramley	300	32	10.6
„ „	816	2	0.2	„ „	180	18	10.0
„ „	682	2	0.2	Antonowka	103	7	6.7
„ „	489	5	1.0	Rev. W. Wilks	126	8	6.3
„ „	600	9	1.5	Sturmer Pippin	300	26	8.6
„ „	275	4	1.4	Newton Wonder	150	14	9.3
„ „	285	10	3.5	Rev. W. Wilks	132	9	6.8
				Lady Sudeley	425	16	3.7
Crimson Bramley	205	8	3.9				
„ „	120	8	6.6				
Duke of Devonshire	229	2	0.8	Encore	48	2	4.1
Doucin	300	21	7.0	Northern Spy	42	12	28.5
Encore	132	3	2.2	King's Acre Pippin	12	3	25.0
French Paradise	80	5*	6.2				
„ „	125	26*	20.8				
Golden Spire	120	7†	5.8	Cox's Orange Pippin	70	7	10.0
„ „	244	11†	4.5	Beauty of Bath	61	10	16.3
„ „	467	26†	5.5				
„ (emasculated and not pollinated	158	12*	7.5				
Golden Russet	450	9	2.0	St. Edmund's Russet	36	1	2.7
Grenadier	200	5	2.5				
King's Acre Pippin	370	6	1.6	Encore	34	4	11.7
Lady Sudeley	153	2	1.3	Cox's Orange Pippin	169	23	13.6

* All of the Apples had no seeds.

† Some of the Apples had no seeds.

	Selfed.				Crossed.		
	Flowers.	Fruit.	%set.	Pollinated by	Flowers.	Fruit.	%set.
Lane's Prince Albert	38	0	—	Newton Wonder	131	8	6.1
,, ,,	409	1	0.2	Lord Grosvenor	210	35	16.6
,, ,,	385	4	1.0	Encore ..	90	9	10.0
				Lord Derby ..	134	8	5.9
Lord Derby ..	606	10*	1.6				
,, ,,	40	4†	10.0				
Lord Grosvenor	250	11	4.4	*Pyrus Neidwetzkiana*	29	13	44.8
Newton Wonder	334	5	1.4	Lane's Prince Albert	115	6	5.2
Nonsuch Paradise	21	1	4.7				
,, ,,	14	2	14.2				
Norfolk Beauty	67	0	—	Bramley's Seedling	141	2	1.4
,, ,,	143	4	2.7	Rev. W. Wilks	93	9	9.6
				Crimson Bramley	147	2	1.3
				Cox's Orange	257	7	2.7
Northern Greening	211	0	—	Royal Jubilee	126	18	14.2
,, ,,	302	2	0.6	Bramley's Seedling	70	14	20.0
Rev. W. Wilks	168	7	4.1	Beauty of Bath	13	1	7.6
,, ,,	200	8	4.0				
,, ,,	221	10	4.5				
,, ,,	106	9	8.4				
,, ,,	237	22	9.2				
Royal Jubilee	472	0	—	Lane's Prince Albert	62	10	16.1
,, ,,	151	0	—	Northern Greening	70	10	14.2
,, ,,	244	0	—				
,, ,,	150	1*	0.6				
St. Edmund's Russet	210	9	4.2				
St. Everard ..	101	6	5.9	King's Acre Pippin	10	2	20.0
,,	48	3	6.2	Beauty of Bath	37	4	10.8
Stirling Castle	873	68	7.7	Cox's Orange Pippin	110	7	6.3
Sturmer Pippin	91	1	1.0	Cox's Orange Pippin	130	14	10.7
Winter Ribston	297	0	—	Encore ..	56	6	10.7
(Orleans Reinette)	309	2	0.6				
Worcester Pearmain	440	7	1.5	Bramley's Seedling	330	22	6.6

* All of the Apples had no seeds.

† Some of the Apples had no seeds.

FIG. 27.

BIGARREAU DE SCHRECKEN (GROUP 2).

(Lower Branches on left-hand side), 81 flowers self-pollinated, no fruit set. (At top of tree), 424 flowers crossed Bigarreau Frogmore (Group 2), no fruit set. (Branch in centre of tree), 195 flowers crossed Knight's Early Black (Group 1), 59 fruits set. (Lower branch on right-hand side), 101 flowers crossed Early Rivers (Group 1), 49 fruits set.

FIG. 28.

BEDFORD PROLIFIC (GROUP 1).

(At top of tree), 107 flowers were self-pollinated, no fruit set. (Lower branch on left-hand side), 34 flowers crossed Black Tartarian "A" (Group 1), nothing set. (On right-hand side), 30 flowers crossed Bigarreau Frogmore (Group 2), 29 fruits set.

FIG. 29.

BIGARREAU DE SCHRECKEN (GROUP 2).

(On right-hand side), 181 flowers crossed Bigarreau Frogmore (Group 2), no fruit set.
(On left-hand side), 109 flowers crossed Black Heart, 46 fruits set.

Fig. 30.

Northern Greening.

(Right-hand side of tree), 211 flowers self-pollinated, no fruit set. (Left-hand side), 70 flowers crossed Bramley's Seedling, 14 fruits set=20 per cent.

FIG. 31.

COX'S ORANGE PIPPIN.

(Left-hand side of tree), 339 flowers selfed, no fruit set. (Right-hand side), 425 flowers crossed Lady Sudeley, 16 fruits set=3.7 per cent.

NOTE.—A good crop set × Lady Sudeley although only 3.7 per cent. of the flowers formed fruits which reached maturity.

FIG. 32.

COX'S ORANGE PIPPIN.

(Right-hand side of tree), 682 flowers selfed, 2 fruits set. (Left-hand side), 300 flowers crossed Sturmer Pippin, 26 fruits set=8.6 per cent.

Fig. 33.

Late Orange (Group 2).

At top of tree (right-hand side), 184 flowers self-pollinated, no fruit set. (Left-hand side), 105 flowers crossed President (Group 2), no fruit set. (Centre of tree), 78 flowers crossed Jefferson (Group 1), 19 fruits set. (Bottom of tree), 94 flowers crossed Coe's Violet (Group 1), 32 fruits set.

FIG. 34.

EARLY TRANSPARENT.

216 flowers on the tree; all were self-pollinated. 131 fruits set and matured. =60.6 per cent.

THE IMMUNITY OF APPLE STOCKS FROM ATTACKS OF WOOLLY APHIS.

(*Eriosoma lanigera. Hausmann.*)

PART I. THE RELATIVE RESISTANCE OF DIFFERENT ROOT STOCKS.

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The work of testing the resistance to Woolly Aphis of the Apple Stocks in commercial use in this country was first suggested by Professor H. M. Lefroy, and it is being carried out in association with the East Malling Fruit Research Station ; it was commenced in February, 1921.

Woolly Aphis is a pest of the first order is this country ; and it has never been easy of control on a commercial scale. It has been realised for some time that it is hardly a feasible proposition to spray, owing to the large quantities of wax secreted by the aphides, and the costliness of sprays which will dissolve this wax ; further, no spraying will deal with the root form, from which the branches again become infected. Therefore the use of root stocks with a high degree of resistance or with complete immunity from the pest is very desirable.

Although the resistance of the root system is most important, the importance of that part of the stock aboveground should not be minimised, since if the above ground portions could be kept free from attack, although little or none of the " stem " of the stock remains above ground after the permanent planting of the tree, yet it would become to some extent, an obstacle to the infection of the roots, and it might even be worth while to " work " trees of known susceptibility high up on stems of known resistance instead of at or about ground level as is the case at present. The resistance of the aerial portion of the stock has also been studied in the hope that the general causes of resistance might be brought to light; the aerial portion being more easy of access. Greater attention will be given to the question of the root system this year.

Thanks are due to Professor H. M. Lefroy for suggesting the investigations, for the interest he has taken and the help he has given me throughout. I also have to thank Mr. R. G. Hatton for kindly supplying the stocks required and for much help in other ways, on the pomological aspect.

The discussion on the possible causes of immunity and resistance, together with other considerations not yet dealt with, will be embodied in a further

paper. The present account is essentially of a preliminary nature. Its main object is to indicate to what extent the present race of Apple Stocks in common use in this country are susceptible and resistant, root and branch, to attack. It has long been traditionally believed that both the so-called " Free " or " Crab " and " Paradise " stocks were more or less highly susceptible. Now that considerably more light has been shed upon the root stocks for Apples, it was decided to make a systematic test of various types of root system so as to obtain really accurate information. This became all the more important since it hardly appears likely that the Northern Spy stock, which has generally been reputed to be immune, would for several reasons that cannot be dealt with here, ever be a popular stock in this country.

The Stocks Used.

It was therefore decided to test for degrees of resistance :—

Series :—(*a*) The so-called " Paradise " stocks in circulation in W. Europe —i.e., the sixteen types described, classified and experimented with at East Malling.

These types were known to contain a series of dwarf and vigorous growths, of fibrous and coarse rooters, and generally to exhibit about as wide a range of characters as possible.

(*b*) Seedling " Free " Stocks raised in the ordinary commercial manner from pips of cider varieties.

As these stocks have also been shown to exhibit wide variations it was decided by considerable infections to ascertain the likely percentage of immunes and even resistants to be found in such indiscriminate seedlings.

(*c*) Certain vegetatively raised Stocks of reputed " Crab " or " Wilding " origin ; these so-called " Wildings " or local " Crabs " to be found in the woods in many districts have long been reputed to be exceptionally hardy.

Some of these " Wildings " seedlings were also kept under observation and experimented with where they were found growing in a wood in North London.

(*d*) Northern Spy, Winter Majetin, and other named varieties of Apple reputed in this country, on the Continent and Overseas, to be either immune or highly resistant.

The object was to make certain whether under different soil and climatic conditions these characteristics would hold good.

The completion of this initial part of the programme has not yet been fully realised, but sufficient indications have been attained under each group to afford useful information.

Treatment of Material.

With the exception of the seedling " Frees " and the " Crabs " found in the wood in North London, the stocks were all kept in large pots. The potting soil was as nearly constant throughout the series as could be contrived, without elaborate precautions. Watering was carried out regularly and was evenly distributed over the stocks. Pruning was not resorted to since it was considered desirable that the infections should not be disturbed more than necessary. All the material save Winter Majetin was unworked material growing on its own roots. Winter Majetin could not at that time be obtained on its own roots and was obtained on paradise roots (Improved Doucin Type V.) originally for purposes of stem infection. As will be seen later the combination gave some interesting results.

The stocks were not isolated since it was particularly necessary that the Woolly Aphis should have full chances of running through seven hundred odd stocks, in order that resistant stocks should stand out clearly ; in addition the expense, and greater space required had to be considered.

The stocks were four abreast, in a single line. Infections were made in successive blocks, as far removed from each other as possible ; any infection noted in a section of the stocks not artificially infected was cleaned off. By these methods the date of infection of all the stocks, which were numbered, was known to within a few days. Subsequent natural cross-infection had to be ignored, but the stocks were growing closely and regularly together ; so that the final results were fairly accurate.

Above ground, the stocks were most easily infected on the young wood, particularly water shoots, it becoming increasingly difficult as the lower portions were tried. The axils of the leaves were uniformly easy to infect on the lower part of the stem and easier still near the tip. It is interesting to note that, often no infection could be made at the base of the stock. But, on the other hand, the progeny of those individuals who had settled down on young wood seemed able to infect the base. The writer is at present unable to explain this.

Wound tissue on any part of the stock is easily infected, as is also any fresh wound. Buds can seldom be infected ; this may also be said of fruit and leaves ; the writer has seen several instances, one being a case in which the aphids were in the centre of the fruit having probably gained entrance through the calyx tube. This has also been observed by Hewitt (*Journal of Economic Biology*, July, 1913).

Bramley Seedling, James Grieve, Early Victoria, and Cox's Orange Pippin were used to keep a good supply of Woolly Aphis for use, since these varieties are all very susceptible.

Characters used in comparing resistance of Stocks :—

The most accurate character, for comparing the resistance of stocks was found to be that of the size of the gall, taken into consideration with the time required for it to form.

The size of the gall was judged by considering the greatest diameter of the galled portion of the stem, relative to that of the ungalled portion immediately above or below. When the galled portion of the stem was about twice the diameter of the ungalled portion, the gall was considered to be large. In a case where the galled portion was only half as large again as the ungalled portion, the gall was deemed to be of a medium size. The term " slight " was given to any gall distinctly smaller than a medium one.

The method of judging the resistance, though rough, worked very satisfactorily ; though fine shades of distinction between closely allied stocks were impossible, it was found to be sufficient to place them into a number of well-defined groups. The resistance of the stocks to the root attack was arrived at in a similar way to that given above.

Method of Making Infections :—

All the material for making the infections was obtained from a wild crab-tree in the outskirts of North London, the fewest possible demands being made on it. Subsequent infections were taken from the stocks already infected, in order that there should be as pure a strain of the aphid as possible. At the Chelsea Physic Gardens there was little likelihood of outside infection, in spite of the fact that the stocks were not covered or isolated in any way.

It was at first thought that if a twig, infected with Woolly Aphis, was attached to a suitable portion of the stock the aphids would walk off and settle down ; this, however, proved not to be the case, since they continued to feed off the stem, as long as it remained moist, and then died " in situ." Their deaths were probably due to the drying of the bark which, in shrinking, gripped the stylets ; as the stylet is cast off at each ecdysis, those aphids which were ready to moult in all probability escaped.

The most satisfactory method of infecting was found to be by means of a brush. The aphids were carefully brushed off into a Petrie dish and transferred in a similar manner to the stocks. Roots were also infected by this method.

A small pit was scraped out, to such a depth as to allow the roots to lie at the bottom. The aphids were then placed on the roots and the pit covered with the lid of a Petrie dish. A circular piece of strawboard was then laid inside so that all light might be excluded from the pit. The infections could then be observed by lifting out the strawboard ; the dish was removed and the pit filled in when the infection was considered satisfactory.

A near approach to natural conditions was thus made,

Resistance of "Paradise" Stocks, Types I.-XVI. (Series A.), and layered "Crab" Stocks F. and H. (Series C.).

(1) *Resistance above ground* :—

The degrees of resistance of the stocks were not sufficiently varied for the stocks to be arranged in order.

They were therefore placed in four groups, as below :—

1. Large galls formed within about five weeks from infection (i.e., very susceptible).
2. Medium-sized galls formed within about one month from infection (i.e., susceptible).
3. Slight galls only showing two months after infection (i.e., resistant).
4. No galls apparent at all (i.e., immune).

It should be clearly understood that the order of the stocks within the above groups has no significance because it has been difficult to allocate a position for those stocks which are on the border line between two groups, the grouping is, of necessity, somewhat rough. Selections have been made from the list of stocks and uninfected specimens of these will be re-infected next year. The grouping, in order of resistance, for those stocks infected at Chelsea Physic Garden, is given below. These results will be tested by re-infection next year.

Group 1 :—

Type I. (Broadleaved English Paradise.)
Type II. (Doucin.)
Type III. ("Hollyleaf.")
Type V. (Doucin Ameliore.)
Type VI. (Nonsuch.)
Layered "Crab" F. (Of French origin, but growing at East Malling to compare with "Paradise." Large leaved, vigorous growing type.)

Group 2 :—

Type IV. (Dutch Paradise.)
Type VII. (Possibly old English Paradise.)
Type XI. (Unnamed type of vigorous "Paradise.")
Type XII. (Unnamed type of very vigorous "Paradise.")
Type XIV. (Unnamed type of very vigorous "Paradise.")

Group 3 :—

Type VIII. (French Paradise.)
Type IX. (Jaune de Metz.)
Type X. (Unnamed type of very free growing " Paradise.")
Type XIII. (Unnamed type of very free growing " Paradise.")
Type XV. (Unnamed type of very free growing " Paradise.")

Group 4 :—

Layered " Crab " H. (Of French origin, but growing at East Malling to compare with " Paradise " types. Small leaves, very spiny, dwarfish growth.)

It will be noticed that Type XVI. has not been placed in any of the groups ; it is omitted since its position is not yet finally decided on. It will, however, probably be found to lie in Group 3.

It is interesting to note that both vigorous and dwarfing types appear indiscriminately in the various groups.

(2) *Resistance below ground :—*

The same system of grouping has been used as for the resistance above ground. The degrees of resistance to the root attack are perhaps less marked than in the case of the attack above ground ; this is probably due to the fact that less galling takes place on the roots than on the stem, in any one year. Some time must elapse before any really definite grouping can be given, though the list given is not thought to be seriously incorrect. Groups 1, 3 and 4 are unlikely to be altered, but several members of Group 2 may be removed to Group 1, after further tests have been carried out ; a great deal more work on the resistance of the roots will be undertaken this year.

The grouping in degrees of resistance is here given for the stocks infected at Chelsea Physic Garden :--

Group 1 :—	*Group* 2 :—	*Group* 3 :—	*Group* 4 :—
Type III.	Type I.	Type VII.	Crab H.
Type VI.	Type II.	Type IX.	Type XVI. (as far as known at present).
Crab F.	Type IV.	Type XII.	
	Type V.	Type XV.	
	Type VIII.	Type X.	
	Type XI.		
	Type XIII.		
	Type XIV.		

It is interesting to note that two varieties so widely different in their root characters as Broadleaf (Type I.) and Doucin (Type II.) appear side by side in their degree of susceptibility.

In order that some comparison may be made between the combined resistance characteristics of the root and stem of each of the various stocks the following table is given.—

Resistance or Susceptibility to attack equal on stem and root.	Resistance to attack greater on root than stem.	Resistance to attack greater on stem than root.
Crab Type F. (G1)	Type I.	Type VIII.
Type III. (G1)	Type II.	Type XIII.
Type IV. (G2)	Type V.	—
Type VI. (G1)	Type VII.	—
Type IX. (G3)	Type XII.	—
Type X. (G3)	(Type XVI ?).	—
Type XI. (G2)	—	—
Type XIV. (G2)	—	—
Type XV. (G3)	—	—
Crab Type H. (G4)		

N.B.—Type XVI. is, as far as is known at present, more resistant on the root than on the stem ; it is probably completely immune on the roots.

Seedling Free Stocks.

Series (*b*).—These stocks were raised at East Malling Research Station from cider-press pulp and showed very great diversity of form ; it was thought possible that some amongst them might stand out as resistant. No attempt was made to group the stocks in any way. When any stocks showed themselves to be highly resistant, or immune, it was intended that they should be propagated and tested for their suitability as stocks. The stocks were dealt with in four series, as follows :—

Series 1.—This series consisted of 100 seedlings, infected on the ground at East Malling in two batches of 50. In order that the infection might not spread to the surrounding stocks, they were enclosed by means of corrugated iron and light sacking. After their removal the ground was subsequently disinfected.

The seedlings were infected in July, 1921, and examined carefully the following June. A heavy infection was produced and was well distributed amongst them. Growing very close together, as they were, the conditions were such as lent themselves well to the experiment.

The seedlings were examined both on the roots and on the stem, and none were found which could be classed as highly resistant ; all being badly attacked to a varying extent.

Series 2.—This series, consisting of 99 seedlings, was transferred to West Malling, the garden of Mr. Norman Grubb, which was known to be infected with Woolly Aphis. These were left to become infected naturally. All of them showed infection on the branches during the first summer (1922).

All of them were badly galled above ground, but the same could not be said of the roots. The final examination took place in January, 1923. Woolly Aphis was then evident only on the roots of three of the seedlings, slight galls being also present on these and on eleven others. On the roots of the remainder, numbering 85, no trace of Woolly Aphis, or of galls, was found. This cannot be taken as indicating the presence of 85 seedlings which are immune on the roots, since the percentage appears much too high in relation to the results obtained on the other 100 stocks from the same source, i.e., those used in Series 1. Series 2 was growing in ground which had been highly cultivated for some years and contained, in addition, a high percentage of coal ashes and had been used for a time as a poultry yard. It was, therefore, thought that the conditions might possibly be unfavourable to the infection of the roots by Woolly Aphis and not that the seedlings were resistant.

A number of the seedlings had died and the roots of most of them were in a very poor condition. Twelve of the healthiest were selected, six of which were replanted on the same ground. The remaining six were transferred to Chelsea. Further efforts will be made during this year to obtain root infections on them and it is confidently expected that this will successfully be carried out at Chelsea.

Should the result of the West Malling infections be the same after further attempts, soil analyses will be carried out, in an attempt to explain it.

Series 3.—This series consists of 100 seedlings and was planted in the open at Chelsea Physic Garden. They were infected in 1922 during June and July. Nothing can be said at the present moment, concerning any possible resistance of the roots, since they will not be examined until March or April of this year. It is, however, clearly established that none of them are immune above ground, although there are indications of resistance to various degrees, all of which are but slight.

The results of the experiments on these three series of seedling free stocks clearly shows that while varying degrees of resistance are fairly common, complete immunity is very rare. Highly resistant varieties are very nearly as rare.

Series C. (*Wildings*).—It was considered possible that resistant or immune varieties might be sought for with greater success amongst wild "crabs." A wood in North London was selected for observations, and it was found that the extent to which the various trees were attacked by Woolly Aphis was very marked. A selections of seedlings likely to have the desirable qualities of

resistance was made by a combination of the observed condition of the trees, the result of infection experiments, and a detailed examination of the trees by means which will be described in a later paper.

Four seedling trees were finally selected as being immune or highly resistant, and well worth testing for their suitability as stocks. They have been given numbers as below :—

*S*1. Tree very spined at the centre. Very little blossom or fruit. All attempts to infect this tree with Woolly Aphis have failed.

*S*2. Tree very spined in the centre, the remainder not to so great an extent. The new wood is not so spined. Highly resistant to Woolly Aphis.

*S*3. A few large blossoms present, but no fruit. Immune above ground. Immunity below ground not absolutely certain.

*S*4. Generally spined but particularly in centre, little blossom or fruit present. Slight attacks of Woolly Aphis on the tips of young wood only.

*S*1 and *S*2, so far, appear to have the most resistant root systems. Owing to the difficulty of testing the wild " crabs," given above, in their natural state, particularly on their roots, further tests must be carried out. These will be begun as soon as they have been propagated vegetatively.

It is interesting to note that all of the above " Wildings " are very similar in their general characteristics to the layered " Crab " H, of the Malling Series of French Wilding " Crab " stocks.

Wood of these Wilding selections has been sent to East Malling for propagation purposes, and, it is thought that at least one of the types is well worth testing for use as a stock.

Series (*d*) *Named Varieties of Apple.*—Of the named varieties of apple only two will be dealt with in this paper, viz., Northern Spy and Winter Majetin, i.e., those that have already been used for stock purposes overseas.

I. Northern Spy.

After many attempts to infect six stocks, both above and below ground, this variety has shown itself to be immune as has been stated by other writers. The aphids settle down for a very short time in some cases, but cannot feed for long ; and, of course, they never form galls. (This question will be dealt with in Part II.)

It has already been stated that, for several reasons, it is not considered that Spy stock will be suitable for all purposes in this country. It therefore remains to be seen how far its character of immunity can be passed on to its seedlings. With a view to pursuing this subject further, joint work has already been agreed upon between Mr. M. B. Crane of the John Innes Horticultural Institution, Mr. R. G. Hatton, East Malling Research Station and the writer of this article.

The first batch of seedlings (i) Doucin (Type II) crossed with Spy, have already been received from Mr. Crane for testing.

II. Winter Majetin.

Winter Majetin has not yet been tested on its own roots. All the material was worked on Type V. root systems. Attempts to infect them resulted in a heavy root infection, the aerial infection being entirely absent and all subsequent attempts failing.

The results given are particularly interesting.

SUMMARY OF RESULTS OBTAINED.

The result of definite infections of types of Apple stocks in commercial use in this country with Woolly Aphis (*Eriosoma lanigera Hausmann*) have shown that :—

(i.) Complete immunity is very rare ; a high degree of resistance of root and branch is also rare.

(ii.) None of the true types of so-called " Paradise " are immune to Woolly Aphis, though there are very marked differences in degrees of resistance both above and below ground. Of the Paradise stocks most highly recommended by East Malling for other qualities, Types XVI, IX, X and XV show a considerable degree of combined resistance, whilst Type XII shows resistance below ground, and Type XIII above. Of the Types not generally recommended for some undesirable quality, Type VIII exhibits resistance above ground and Type VII below.

(iii.) Amongst indiscriminate Seedling " Free " Stocks, there are similar degrees of resistance, but the character of immunity appears to be very rare.

(iv.) Amongst Wilding " Crabs " of particular types, preliminary investigations seem to show that immunes are to be found, though many " Wildings " also appear highly susceptible. Of the two immune " Wildings " so far tested, one was on its original roots, the other had been multiplied by vegetative methods. An immune individual can therefore safely be multiplied vegetatively. Layered Crab H, the merits of which as a stock, are as yet not fully ascertained, is referred to.

(v.) Northern Spy under English conditions is immune both root and branch ; Winter Majetin, which has so far only been tested for branch susceptibility, is immune also.

(vi.) The same degree of root and branch resistance, however, does not always go together. The degree of resistance to attack is about equal above and below ground in eight cases. In six cases the resistance is greater below ground than above, and in two vice-versa.

(vii.) A stem immune plant, in the case of Majetin, has been shown capable of retaining its immunity though worked on a susceptible root (Doucin Ameliore Type V). How far this is of general application is being tested further.

(viii.) There seems no obvious connexion between either vigour and dwarfingness, or fibrous roots and coarse roots, and susceptibility and immunity to Woolly Aphis.

(ix.) Above ground, wound tissue, young wood and water shoots are most easily infected. Such points as these have not yet been decided with regard to the roots.

In conclusion it may be added that a joint programme of work is still in progress upon the subject.

Two lines of especial interest are being pursued; the search amongst existing immune plants for individuals which might combine the other desirable characteristics which have been found amongst the known Apple stocks, and the systematic breeding of new plants combining these characters with immunity.

Bibliography.

A more complete bibliography will be given with Part II of this paper. The papers mentioned below are those which have some direct bearing on the work here described.

1. *French.* Handbook of Destructive Insects of Victoria, Part I Chapter VI.
2. *Hewitt.* Journal Econ. Biol., July, 1913.
3. *Buckton.* Monograph of British Aphids.
4. *Baker.* Report 101, U.S. Dept., Agric., March, 1915.
5. *Board of Agriculture Leaflet.* No. 34.
6. *Theobald.* Journal of Pomology, March, 1921, "The Woolly Aphid of the Apple and the Elm." Part I.
7. *Barker and Spinks.* Investigations on Apple Stocks, Annual Report of Agric. and Hort. Station, Long Ashton, 1917.
8. *Hatton.* Paradise Apple Stocks. Journal of Royal Hort. Soc., Vol. XLII, Parts II and III, 1917.
9. *Hatton.* "Suggestions for the Right Selection of Apple Stocks." Journal of the Royal Hort. Soc. Vol. XLV, Parts II and III, 1920.

DATA ON THE LATERAL SPREAD OF THE ROOTS OF FRUIT TREES.

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The distance apart at which trees of the different fruits should be planted in the orchard is a subject of great importance to the commercial grower and one on which decisions must be greatly helped by a knowledge of the lateral spread of the roots of fruit trees. The policy of interplanting with "filler" trees or bush fruits, and the length of time which these may be allowed to remain without seriously competing with the permanent trees, should be guided by a knowledge of the rate of growth of lateral spread and depth below ground level of the major portion of the roots of the latter. Unfortunately the importance of the last two factors is not appreciated to the same extent in this country as in most of the big fruit growing centres abroad with serious results in many cases both to the growth of the trees and evenness in the size of the fruit.

In addition, this subject is extremely important at a Research Station where it is often essential that trees under treatment shall be free from competition with the roots of surrounding trees.

For the above reasons it was therefore decided to make examinations of the roots of trees of varying ages of the different orchard fruits as material became available, noting the length of the main roots and their depths below ground level.

The initial work was commenced in 1921. Although the material then available was not in all cases satisfactory, it was felt that it might prove of value in determining the best method of carrying out the work.

The results for that year which were published in full in the Report of this Station for 1921 may be briefly summarised as follows :—

Example I.—Norwegian Cherry—Standard Tree—15 years from bud. Lateral spread of roots approximately 30′.

Example II.—Apple, Bramley's Seedling—Bush Tree—19 years old. Lateral spread of roots approximately 10′ 6″. Note—This Tree had been transplanted when 9 years old.

Example III.—Apple, King of the Pippins—Bush Tree—19 years old. Spread of one root examined 10′ 4″. An extremely poor tree and so figures are probably sub-normal for a tree of this age.

Example IV.—Apple, King of the Pippins—Bush Tree—19 years of age. Spread of one root examined 8′ (total length 13′ 2″).

Examples V., VI. and VII.—

Plums { Pond's Seedling / Victoria / Early Transparent Gage } Bush Trees—16 years old.

Lateral spread of roots examined approximately 9′ 6″ with one exception of 12′ 8″.

Example VIII.—Plum, Early Transparent Gage—Bush Tree—16 years of age. Lateral spread of root examined 4′ 8″. A very poor tree—considerably below normal.

Example IX.—Broadleaved Paradise Stock—One year's growth after removal from parent stool. Length of longest root 22″.

Example X.—Apple, Stirling Castle—3 Bush Trees—4 years old (2 years in site). Lengths of longest roots—

Tree (*a*) 5′ 9″.
(*b*) 4′ 9″.
(*c*) 4′ 6″.

Example XI.—Apple, Allington Pippin—5 Bush Trees—3 years old (2 years in site). Lengths of longest roots—

Tree (*a*) 4′ 3″.
(*b*) 4′ 8″.
(*c*) 4′ 10″.
(*d*) 5′ 3″.
(*e*) 7′ 1″.

Although the material available was not in all cases so vigorous as might have been wished, yet the data obtained brings out several interesting points. Example I., and the eight trees in Examples X. and XI., may be considered first class material, and in these cases length of root found was considerably in excess of general expectation. In the remaining examples the material was distinctly poor and the lateral spread cannot be accepted as normal, but the depths of the roots below ground level varied but little from those of the normal examples, and the sum total of the evidence suggested that under soil and climatic conditions at this Station, at least the trunks of the main roots are generally within the top 20″ of soil except in certain cases where the roots, after running for some distance in a more or less horizontal direction, suddenly strike vertically downwards. This curious habit was encountered several times. In one case the last 43″ of the root descended in a true vertical plane. It was quite apparent that a number of lesser roots and laterals of the main roots descended to a greater depth than 20″, but the depth of the main roots may be taken as a criterion

as to the region of maximum root population. It is interesting to note that a somewhat similar state of affairs has been found in the Hood River Valley, Oregon, where it was found that the majority of the feeding roots of fruit trees of bearing age were located from 3 to 10 inches below the surface of the soil[1], in Ohio[2], and in Maine[3].

The method adopted this year has been to select at least the six largest roots and to follow them from their point of origin at the trunk to their apices, making at the same time notes on any variations in their depths below ground level.

The material used was composed of Apple trees of cider varieties, 16 years of age from the bud, which had been growing as standard trees in a grass orchard for the last 12 years.

This orchard has been heavily stocked for a great many years, and during the last four seasons has been used for raising pigs on the "out-of-doors" system.

The trees which were approximately one-third the size of mature trees, were in excellent condition, and in this respect may be considered normal material.

The stocks concerned are "free" stocks, and exhibit to some extent the variations in type of growth which exist even among the strong "free" stocks.

Owing to lack of space available, detailed tables of the measurements taken are omitted. The measurements from the apices of the roots in direct lines to the points where the roots arose from the trunks have been included in order to give a more accurate picture of the radius of root spread.

The depths of the lesser roots were taken at a distance of 3′ 6″ from the trunks, and with the exception of Example No. IV. the trunks of all the more important roots were traced and measured. Owing, however, to lack of space, the former are omitted, since few of them vary to any great extent from the larger roots, and only six typical large roots of each tree examined are shown in diagram.

Tracing was not continued once a root was found to be striking downwards vertically on account of the large amount of labour required.

Example I.—Variety—Eggleton Styre. Length of Roots:—

(1) Fig. 1A. Actual length, 20′ 5″; Apex of root from trunk, 18′.

This root extended into a portion of the orchard which was ploughed in the Spring of 1922, and was cut off by the plough when $\frac{7}{16}$″ in diameter. The detached portion could not be traced and so the figures given do not represent the full length of the root.

(2) Fig. 1A. Actual length, 23′ 4″; Apex of root from trunk, 20′ 8″.

(3) Fig. 1A. Actual length, 23′ 5″; Apex of root from trunk, 22′ 6″.

This root when $\frac{1}{4}$″ in diameter had been cut by the plough as in the case of (1).

(4) Fig. 1B. Actual length, 19′ 2″; Apex of root from trunk, 14′ 10″.

(5) Fig. 1B. Actual length, 25′ 4½″; Apex of root from trunk, 20′ 2″.

(6) Fig. 1B. Actual length, 18′ 5″; Apex of root from trunk, 15′ 1″.

Root struck vertically downwards and at a depth of 28″ was ¼″ in diameter.

As will be seen from the diagrams, the trunks of the main roots are in this case contained within the top 20″ of soil. Detailed measurements were taken of all other important roots but no marked variation was found.

Taking into account the fine terminal sections of the roots which it is almost impossible to trace, the average radius of the root spread of this tree would appear to be approximately 20′.

Example II.—Variety—Sweet Alford. Length of roots:—

(1) Fig. 2A. Actual length, 16′ 11″; Apex of root from trunk, 15′ 11″.

Root struck down vertically when ⅛″ in diameter.

(2) Fig. 2A. Actual length, 15′ 3″; Apex of root from trunk, 14′ 8″.

This root when $\frac{3}{16}$″ in diameter had been recently broken by pigs. Measurements could not be taken beyond this point.

(3) Fig. 2A. Actual length, 14′ 6″; Apex of root from trunk, 13′ 8″.

Root struck downwards vertically when ⅛″ in diameter.

(4) Fig. 2B. Actual length, 17′ 1″; Apex of root from trunk, 15′ 1″.

Root struck downwards vertically when $\frac{3}{16}$″ in diameter.

(5) Fig. 2B. Actual length, 17′ 6″; Apex of root from trunk, 16′ 9″.

Root struck downwards vertically when $\frac{3}{16}$″ in diameter.

(6) Fig. 2B. Actual length, 11′ 3″; Apex of root from trunk, 10′ 4″.

Generally speaking, this tree was shallow rooted as the term is usually understood.

Only a few small roots struck downwards from under the tree.

The average radius of root spread would appear to be about 15′.

Example III.—Variety—Royal Jersey. Length of roots:—

(1) Fig. 3A. Actual length, 25′ 10″; Apex of root from trunk, 24′ 4″.

(2) Fig. 3A. Actual length, 19′ ½″; Apex of root from trunk, 17′ 8″.

Root struck downwards vertically when $\frac{3}{16}$″ in diameter.

(3) Fig. 3A. Actual length, 20′ ½″; Apex of root from trunk, 12′ 8″.

Root struck downwards vertically when $\frac{3}{16}$″ in diameter.

(4) Fig. 3B. Actual length, 17′ 11″; Apex of root from trunk, 15′ 5″.

Root struck downwards vertically when ⅛″ in diameter.

(5) Fig. 3B. Actual length, 14′ 9″; Apex of root from trunk, 13′ 11″.

Root struck downwards vertically when $\frac{3}{16}$″ in diameter.

(6) Fig. 3B. Actual length, 16′ 3½″; Apex of root from trunk, 15′ 1″.

It will be seen by reference to Fig. 35 that this stock was extremely surface rooting, some of the roots running for considerable distances within a few inches of the surface and well within the zone of the roots of the grass.

The absence of roots arising immediately under the tree was most marked.

The radius of root spread is again about 15′.

Example IV.—Variety—Knotted Kernel. Length of roots:—

(1) Fig. 4A. Actual length, 11′ 10″; Apex of root from trunk, 10′ 3″. Root struck downwards vertically $\frac{1}{8}$″ in diameter.

(2) Fig. 4A. Actual length, 10′ 1″; Apex of root from trunk, 8′ 6″. Root struck downwards vertically when $\frac{1}{4}$″ in diameter.

(3) Fig. 4A. Actual length, 13′ 8$\frac{1}{2}$″; Apex of root from trunk, 11′ 9″.

(4) Fig. 4B. Actual length, 9′ 7$\frac{1}{2}$″; Apex of root from trunk, 9′ 3″. Root struck downwards vertically when $\frac{1}{4}$″ in diameter.

(5) Fig. 4B. Actual length, 11′ 6$\frac{1}{2}$″; Apex of root from trunk, 10′ 11″. Root struck downwards vertically when $\frac{1}{8}$″ in diameter.

(6) Fig. 4B. Actual length, 19′ 3″; Apex of root from trunk, 19′.

The stock in this example was distinctly "fangy" and deeper rooting than the other three examined. A number of roots of equal size to those traced, struck down from the trunk at an almost vertical angle and could not be followed owing to the large amount of labour necessary.

The "break" of the new roots after planting in the orchard was quite distinct, large numbers of strong roots having arisen from the ends of the original "fangy" roots which had necessarily been heavily pruned when the tree was lifted in the nursery. This dissipation of the growth of the root system appeared to account for the shorter average root in this example and the roots, which had arisen on the inner sides of the old "fangs," tended to continue downwards at steep angles as already stated.

It may be mentioned as a point of interest that this variety which makes a strong and very upright tree, has the reputation amongst nursery hands of inducing very deep rooting by the stock. Being a cider variety, it is, incidentally, always "worked" on untyped "free" stocks.

In this example probably not more than 50 per cent. of the large roots were contained in the first 20″ of soil.

The radius of root spread is in this case only some 10′.

A noteworthy feature of the observations here recorded as in those of 1921, has been the frequency of occurrence of roots which, after pursuing a more or less horizontal course for some distance, suddenly dip in a practically vertical direction and penetrate to a considerable depth. Such cases have been noted in root systems of widely differing ages, some

indeed only three years old. The character of the soil at the point where the abrupt change in direction occurs presents no obvious feature to account for this behaviour, and it may be stated with certainty that it is not associated with the striking of any actual cleft or lighter vein. Appearances suggest that these downward striking roots are the true terminals of each extension growth of the root system. As terminals they seem to be positively geotropic and the vertical habit results, and on reaching depths at which conditions for free

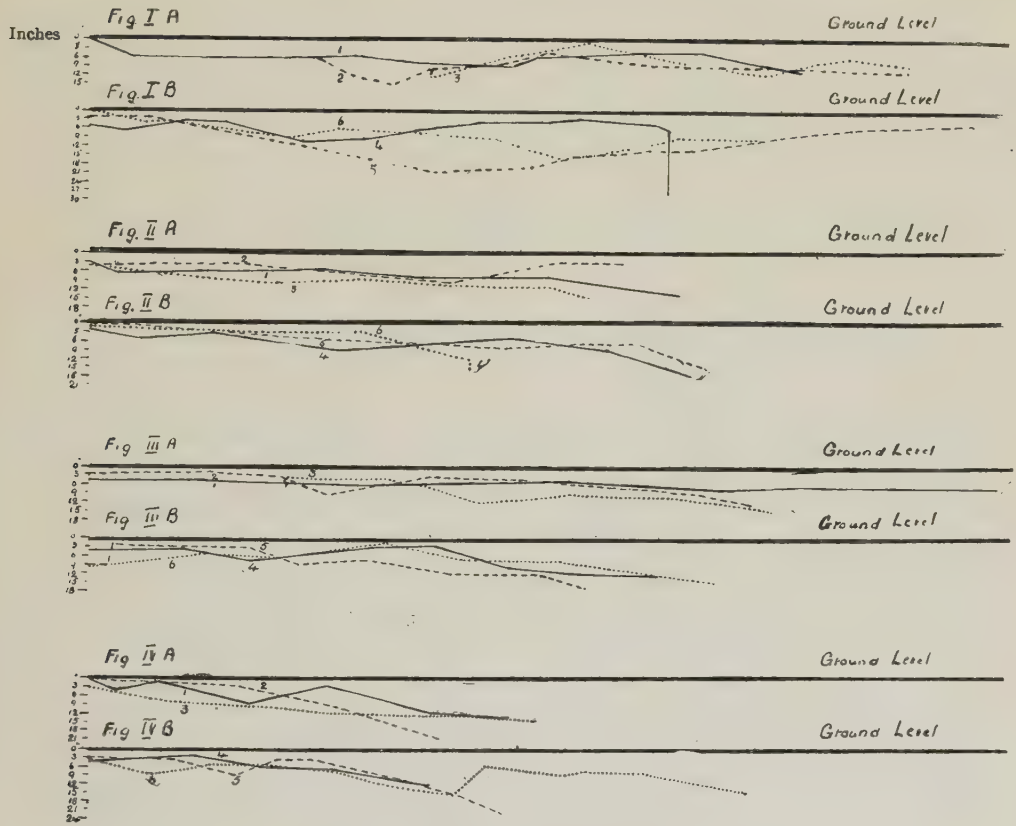

Fig. 35. Depths Below Ground of Roots.

root growth are less favourable, their rate of growth is checked and the laterals immediately behind, which are growing in a more or less horizontal direction, are accordingly stimulated to greater activity and become in effect leaders, for the time being continuing their horizontal course. In turn the latter may ultimately strike downwards and in this way a succession of extension growths in either direction is produced, the horizontally placed being usually the more vigorous by reason of the more favourable conditions. What determines the sudden change from the horizontal to the vertical course can only be surmised

on the evidence at present available; it may, from indications observed, synchronise with the beginning or end of each growing season.

It is interesting to note that under the prevailing local conditions the roots of the "free" stocks frequently penetrated the upper 6" of soil which contained a mass of grass roots. The grass, as already previously mentioned, has always been heavily stocked.

SUMMARY.

From the results of even the relatively small number of root systems examined during the last two years it is evident that in the case of healthy material there must be considerable overlapping of the root systems of permanent trees at the distances at which a large percentage of both bush trees and standards are planted in this country. While in the absence of definite evidence showing the extent of the effect of such overlapping root-systems no quantitative statement can be made; it is hardly to be doubted that the check to growth must in many cases be severe.

The cherry, plums, and apples on Paradise stocks examined in 1921, and with one exception, the apples on "free" stocks examined in 1922 appear to confine the major portion of their root systems to at least the first two feet of soil. This may be due in part to the humid climate of this locality and to the presence of a heavy, poorly aerated subsoil, but other investigations already cited have found that the feeding roots of the bulk of apple trees are much nearer to the surface than has been generally supposed.

When the observations recorded in the two preceding paragraphs are considered in conjunction, some idea may be gained of the congestion of feeding roots which must exist where an orchard of large trees is planted up with soft fruit and the severe competition which must follow when "filler" trees are left in too long.

Considerably more data must be collected before the economic aspect of these observations can be profitably discussed. It is intended to examine during the coming year a number of vigorous young trees on Paradise root stocks.

Bibliography.

1. *Allen, R. W.* Agr. Exp. Sta. Report of the Hood River Branch Exp. Sta. Pp. 20-24. 1914-15.
2. *Green, W. J. and Ballou, F. H.* Ohio Agr. Exp. Sta. Bul. 171. 1906.
3. *Jones, F. R.* A Study of the Development and Extent of the Roots of Apple Trees. 1912. Unpublished Thesis on file in the Library of the University of Maine.

A NOTE ON THE EFFECT OF SULPHUR ON BLACK CURRANT MITE.

By A. H. LEES.

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In the Annual Report for 1919 reference is made to the effect of lime-sulphur spraying on control of Big Bud. This treatment has sometimes been promising and sometimes disappointing. It seemed necessary, therefore, to investigate more closely the action of sulphur on the migrating mites. Lime-sulphur itself is a compound body. It contains polysulphides which, when sprayed on to a plant, deposit a coat of sulphur, at the same time giving off sulphuretted hydrogen. The evolution of this gas lasts, however, for probably a short time only and any continued toxicity of the spray depends most likely on the action of the sulphur itself.

In order to be quite certain of the action of sulphur by itself it was necessary to use it in the pure form and this was done by obtaining a sulphur cloud by means of an air current over the heated substance.* This cloud was projected into a closed glass bell jar and left for three days to allow the coarser particles to settle. The sides of the jar were thus covered with an invisible coating of sulphur.

A black currant twig with some big buds on it was placed with its lower end in water inside the jar. The jar was closed at the bottom by the bench of the laboratory, but had a small opening at the top. The experiment was done in spring, just when mite-migration was beginning, at a temperature that encouraged it.

The following details show the result of the experiment. 1st day—Twig placed inside. 5th day—Heavy migration. Very few living and those just emerged. Some on stem of bud, but dead. Most at bud mouth opening. 7th day—Ditto. 10th day—Ditto, but few living. A few on stem of bud, but dead. 16th day—Ditto. 24th day—All dried up and brown.

Under these conditions, therefore, there was a very decided killing effect, which lasted at least sixteen days even though air diffusion could take place to some extent through the slightly open top.

A similar experiment was done using a deposit of lime-sulphur on the inside of the bell jar. This deposit was well washed with water and dried before use to obviate any danger of the presence of sulphuretted hydrogen. 1st day—

* Barker and Wallace. A New Method of Sulphur Fumigation. 1921 Annual Report, Long Ashton Agricultural and Horticultural Research Station.

Twig placed in bell jar. 7th day—Mites emerging, but all killed. 11th day—Many mites emerged, a few living. None on stem. 13th day—Ditto. Isolated mites on stem. 16th day—Ditto, but more living. Fair numbers on stem, some living. Migration evidently proceeding, though slowly. 22nd day—Ditto. 30th day—All dried up and brown.

The effect seemed to be the same as with pure sulphur, but it did not last quite so long.

A third big-budded twig was treated in a different way. It was held for a few seconds in the path of a sulphur cloud so as to be covered with minute sulphur particles. It was then placed in a moist closed bell jar. 1st day—Twig placed in bell jar. 7th day—Mites emerging but killed. 11th day—Many mites. One or two (newly emerged) living, a few on stems dead. 13th day—Ditto. 16th day—Ditto, but rather more living, especially at opening of bud. Some living on stem of bud. 22nd day—Most dead and dried up.

This method therefore gave about the same control.

The following give the details for an untreated big budded shoot kept in a closed bell jar. 1st day—Twig placed in bell jar. 5th day—Active, living. 7th day—Ditto. All over the stem. 10th day—Ditto. 16th day—Ditto. 24th day—Still active, but only a few emerging.

There was therefore no interference with normal migration by keeping the mites in the close atmosphere of a bell jar. It is indeed necessary to keep them in a rather moist atmosphere as they are very liable to dessication in the laboratory.

Under indoor conditions, therefore, the migration went on for about three weeks, during which time all the sulphur treatments exercised general control. The influence of the lime-sulphur treatment seemed to be weak after the first fortnight and the same applies to a lesser degree to the twig exposed to the sulphur cloud. Probably the supply of sulphur present was becoming exhausted.

These experiments clearly show the great value of sulphur in controlling mites and its effect seems to be very deadly. Its action, however, is limited by its comparatively short duration. In the field mite-migration may be proceeding for two and a half to three months, so a second or third application would appear to be necessary. If lime-sulphur is used, a second or third application must be at summer strength, since foliage has reached a fairly advanced stage, and consequently far less sulphur is deposited at the second or third spraying. A much greater difficulty is, however, the fact that at these two sprayings nearly all the sulphur is deposited on the leaves instead of on the wood and big buds, which positions give the most effective control. In practice a second spraying at summer strength did not appear to increase the control, no doubt for the reasons discussed above.

The only solution to the problem would appear to be either dusting with a very fine sulphur powder or making use of a sulphur cloud. The former, if sufficiently fine powder could be obtained, might result in some burning and also might be troublesome on account of the deposit on the developing berries. The latter method would appear to be very promising but there is at present no machine capable of giving the requisite cloud under open-air and commercial conditions. An attempt is being made to devise a suitable apparatus.

EXPERIMENTS IN THE CONTROL OF THE APPLE SUCKER (*Psyllia mali Schmidberger*) IN THE ADULT STAGE.

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SINCE the control of the apple sucker by spraying for the nymphs is so dependent upon the skill and thoroughness of the operator and since control by either spraying or dusting is a costly proceeding, it was decided to attempt open air tobacco fumigation, the use of which has been favourably reported upon from Russia. For this purpose we had on hand a supply of tobacco stems and spoiled leaf tobacco, as well as a quantity of dust, which we afterwards found to contain a large proportion of non-combustible material.

Three small blocks of orchard, designated A, B and C, were chosen for the tests, the details of which follow.

Block A. This block consisted of closely planted trees, twenty-five to thirty years old, and being situated in a hollow, sheltered on all sides from the wind, presented ideal conditions for the successful application of this method. Furthermore, it was in the very centre of the infestation, the insects being so numerous that, at the slightest disturbance of the limb, the patter of their bodies was like a shower of rain upon the foliage.

Details of Experiment. On August 2nd after a night of rain, the air being saturated with moisture, conditions were considered ideal for the carrying out of the experiment. Small heaps of dry hay were laid throughout the orchard and waste tobacco leaves or stems placed thereon, one heap midway between four trees.

After lighting a few fires it appeared that the material was going to be consumed too rapidly owing to its dryness. Before lighting any more fires, therefore, a small quantity of wet weeds was mowed and placed on each heap. This had the effect of slowing down the fires and preventing them from bursting into flame and the steam given off by the wet weeds seemed to have the effect of producing a denser, heavier smoke. After all the fires had been ignited a slight breeze sprang up, but as it seemed to constantly change its direction, its effect was to cause the smoke to circulate round and round the orchard.

The fires were started at 11 a.m. and some of them smouldered until late in the afternoon, but the period of maximum fumigation could not have been

more than one and a half to two hours. The smoke produced was very dense, hanging low over the orchard and did not rise and become dispersed as rapidly or to the extent that had been expected.

Results. On going through the orchard at 4 p.m. the experiment seemed to have been a great success, for scarcely a living apple sucker was in evidence. Those remaining on the foliage of the lower limbs were for the most part apparently dead, hanging with their tarsi entangled in the pubescence of the leaf. The surface of the ground and the leaves of weeds beneath the trees were also littered with their bodies. It was estimated that the mortality on the lower limbs was at least 99 per cent. In the tops of the trees a somewhat larger number were still alive, but most of these were inactive.

On a sheet with an area of eighteen square feet, the bodies of 1,320 apple suckers were counted. Upon examination the next day 150 showed signs of life. These were placed on apple seedlings and three days later, twenty, or 1.52 per cent. of the total, were found to have apparently regained normal activity.

SUMMARY OF TREATMENT.

Area of orchard, 1 acre.
Number of trees, 50.
Number of fires, 36.
Date of application, August 2nd, 1920.

Materials :

210 lbs. tobacco stems and leaves.
150 lbs. dry hay.
70 lbs. weeds.

Labour :

Laying out material, etc.,	
1 horse and wagon and 3 men,	1 hour
Mowing weeds	45 minutes
Lighting fires, 3 men	30 „
Attending fires, 1 man,	2 hours.

Cost per 50 trees : $8.25.

DETAILED COST OF TREATMENT.

210 lbs. tobacco waste @ 2c lb.	4.20
150 lbs. hay @ $30 per ton	2.25
1 horse, 1 hour, @ 25c per hour	.25
Labour, total 7 hrs. 15 mins., @ 25c per hour	1.82
	$8.52

Block B. This is a small garden orchard of a mixed nature, consisting of trees from twenty to forty years old. It is fairly isolated, being shut in by a high hedge, but in a heavily orcharded locality.

Details of Experiment. Tobacco dust was used in the test and, since the material contained much sand and other incombustible material, our chief difficulty was in getting it to burn satisfactorily. Heaps of hay were scattered through the orchard and the dust carefully sifted through the hay.

On August 13th, the date of application, conditions were very similar to those of the previous treatment, viz., rain the previous night, with a heavy saturated atmosphere. A breeze that came on half way through the experiment was, however, somewhat more steady in its general direction, so that several heaps of material which had been kept in reserve for this eventuality were moved to the windward side of the orchard and ignited, the smoke drifting the entire length of the field before being lost.

Results. The results of this fumigation appeared to be equal to those on Block A on the lower limbs, but a larger percentage in the tree tops remained unaffected, though more material was used. This may be due to the fact that the tobacco dust used was far from pure, 65 per cent. consisting of incombustible material.

SUMMARY OF TREATMENT.

Area of orchard, ½ acre.
Number of trees, 34.
Number of fires, 20.
Time of fumigation, 2 hours.
Date of application, August 23rd, 1920.

Materials :

180 lbs. tobacco dust.
170 lbs. hay.

Labour :

1 horse and wagon,	1 hour.
3 men,	¾ hour.
Lighting fires, 2 men	½ hour.

Cost per 50 trees : $13.27.

DETAILED COST OF TREATMENT.

180 lbs. tobacco dust @ 3c per lb.	5.40
170 lbs. hay @ $30 per ton	2.55
1 horse, 1 hour @ 25c per hour	.25
Labour, 3¼ hours @ 25c per hour	.82
	$9.02

Block C. The area involved in this test was one and one-half acres, but only forty-one trees are included in this area. These are old trees forty to fifty years old and some of them very high.

Details of Experiment. A combination of tobacco stems, leaves and dust was used in this experiment. Just prior to lighting the fires several very heavy showers almost saturated the heaps in the open, and considerably dampened those beneath the trees, the tobacco dust on the top of each heap being reduced to a wet, musty mass.

A few drops of kerosene were accordingly placed at the base of each heap which was then lighted by a torch, consisting of some kerosene soaked rags attached to the end of a pole. In this way two men had all the piles burning in about half an hour.

No sooner were all the fires started than a heavy deluge fell, lasting for one-half hour. However, none of the heaps were completely extinguished, but after being allowed to smoulder for two hours, some of the smaller fires, which did not have enough heat to consume all the material, were lifted with a fork and placed on other heaps which were burning more vigorously.

The fires which were started at 3 p.m. were attended to and drawn together until 5.30 p.m. At 7 p.m. some of the smaller fires were again amalgamated and the orchard was still undergoing a fairly dense fumigation at 9 p.m. Atmospheric conditions between 4 p.m. and 9 p.m. were ideal, there being no wind at all, with the air warm and damp.

Results. Immediately before fumigation and again one day later, a determination was made at three different points in the orchard of the number of apple sucker adults that could be counted from the ground in five-minute periods in order to gain an approximate idea of their relative abundance before and after treatment. The results were as follows :—

1. *Before Fumigation.*
   - (*a*) 5 individuals in 5 minutes.
   - (*b*) 110 individuals in 5 minutes.
   - (*c*) 235 individuals in 10 minutes.

2. *One day After Fumigation.*
   - (*a*) 5 individuals in 3 minutes.
   - (*b*) 3 individuals in 5 minutes.
   - (*c*) 0 individuals in 5 minutes.

Live individuals were somewhat more numerous in the tree tops than indicated in the foregoing, but they were for the most part inactive.

On a sheet of 18 square feet area spread beneath the tree previous to fumigation there fell 361 apparently dead apple suckers. Fifty of these

eventually showed some signs of life and were confined on apple seedlings, but only twelve of these regained their normal activity.

Counts were made five days later in the orchard from the same points as before with the following results :—

10 individuals in 5 minutes.
14 individuals in 5 minutes.
23 individuals in 5 minutes.

At the time this increase was thought to be due, at least partially, to recovery but later experiments indicated that the percentage of recovery is low, while reinfestation from surrounding areas takes place with comparative rapidity. This particular block being surrounded on all sides with heavily infested trees, every condition was favourable for prompt reinfestation. It may be noted that in Block B, the pest was apparently as numerous as ever three weeks after treatment.

SUMMARY OF TREATMENT.

Area of orchard, 1½ acres.
Number of trees, 41.
Number of fires, 36.
Date of application, September 1st, 1921.

Materials :

Tobacco leaves and stems, 400 lbs.
Tobacco dust, 100 lbs.
Wet weeds, 50 lbs.
Kerosene, 1 gallon.

Labour :

1 horse and wagon, 3 men	1 hour.
Mowing weeds,	1 hour.
Lighting fires, 2 men,	½ hour.
Attending fires, 1 man.	2 hours.

Cost per 50 trees : $16.17.

Detailed Cost of Treatment.

400 lbs. tobacco stems and leaves @ 2c per lb. ..	8.00
100 lbs. tobacco dust @ 3c per lb.	3.00
1 gall. Kerosene @ 40c per gal.	.40
1 horse, 1 hour @ 25c per hour	.25
7 hours labour @ 25c per hour	1.75
	$13.40

GENERAL OBSERVATION ON FUMIGATION.

The immediate effect of the fumigation with tobacco waste in the open air without the use of tents was much greater than would have seemed possible. Were it not for the prompt reinfestation of the treated areas, we would be tempted to prosecute this phase of the work much more vigorously.

Were it possible to develop sufficient co-operation to fumigate a large area at one time under careful supervision, it might, even under these circumstances, be worth while to attempt further such treatments on a large scale. The probability of securing the co-operation of every single grower in any large area is not very great, but it might be done. The treatment of the orchards late in August after the period of maximum activity of the apple suckers has ceased, but before egg-laying begins, is a promising line of inquiry.

There is another important item to consider, however, viz., that of cost. At the costs given, which we believe with proper organisation could be reduced considerably, the operation might be economically carried out. It was discovered however, upon attempting to renew our supply of tobacco waste, that it would now cost double the figure given. This supply had been obtained several years ago and since that date the price of the product has increased and the cost of freight still more so. The freight charges alone from Montreal, where our supply is obtained, even when the material is purchased in carload lots, so increases the original cost, that the expense of the treatment under 1920 condition was prohibitive.

It might therefore, be well at this point to summarise the results of our experience in the carrying out of the operation of fumigation.

Our experiments indicate that 360 lbs. to the acre of waste tobacco, free from incombustible material, will give good control under favourable conditions. It is unnecessary to use hay as a starter for fires, as they burn quite well without such assistance. We have used damp vegetation to prevent the material from blazing up, but it seems likely that watering with a sprinkling can would have the same effect and would shorten the work. The fires can be ignited most rapidly by the use of a torch, rather than with matches.

Numerous small fires are better than a few large ones. Where the latter are used on a still day, the smoke has a tendency to ascend directly upwards and be lost. It is of advantage also to have a number of heaps held unlighted in reserve, so that in the event of a wind suddenly arising or changing its original direction, these reserve heaps may be transferred to the windward side of the orchard.

The fall of rain during the process is not particularly to be feared, since our experiments show that once started, the fires keep on burning, even through a heavy shower. It is not advisable, however, to leave heaps out long unlighted

in the rain as this will result in the extraction of a large part of the nicotine. The fires will have to be drawn together several times, as there is a tendency for a part of the outside of the heap to remain unconsumed. In fact, it is advisable to pick up the smaller fires by means of a fork and to add them to those burning more vigorously.

The cost will, of course, vary with the locality, particularly with its proximity to a cheap source of waste tobacco. With tobacco waste at 2 cents per pound, we believe the entire operation could be performed at a cost not exceeding from $8.00 to $10.00 per acre, which compares favourably with that of other treatments.

It must be borne in mind, however, that success could only be hoped for in isolated orchards, or in cases where the operations covered a very large area. Furthermore, to further lessen the amount of reinfestation, it would be advisable to defer treatment as late as possible before oviposition, viz., at the end of August. It is possible that were this done, important reinfestation would not occur.

TESTING OF FRUIT TREES.

In the previous issue of the Journal there was a note showing that the Ministry of Agriculture had co-operated with the Royal Horticultural Society in forming a scheme under which new varieties of fruit could be tested, to discover which possessed merits for commercial purposes.

The scheme is being administered by a Joint Committee of these two bodies, which is known as the Committee for the Testing of Fruit Trees. The Committee have invited the English breeders of fruit trees to send in their new varieties for planting at the Central and Sub-Stations, in order that they may be grown, the results compared and carefully recorded.

At the present time twenty-one varieties of Apples have been received, and these will be grown—in the first instance, at the Central Station—as half-standard trees, and bushes, propagated on suitable stocks. Not less than forty trees of each variety will be cultivated, as the Committee thought that on no less a number could a proper decision be made. Of Pears only two varieties have been sent in. The commercial grower has but a few suitable commercial varieties of Pears and the Committee hope that breeders will, in the course of a few years, be in a position to send in new kinds. Three new varieties of Plums, and a similar number of Cherries have been submitted, and these will be planted and kept under observation.

With bush fruits, some interesting new varieties of Black Currants, eight in all, have been submitted. Some of these are highly spoken of by the raisers. One of Red Currants, five of Raspberries, and three of Gooseberries, have been accepted. At least twenty bushes of each variety of Black and Red Currants, Gooseberries and Raspberries will be grown under approved conditions, and the results carefully recorded.

The trials have been so arranged that amongst the new kinds some well-known existing commercial varieties will be planted. In order that comparisons may be properly and conveniently made. The report will thus indicate to what extent the new kinds are equal to, or preferable to, the older established commercial varieties.

The number of new varieties thus submitted, though not large, is fully up to the expectations of the Committee for this season ; but it is expected that as the scheme becomes more widely known, the number of varieties will annually increase. Raisers of new varieties might note that the Committee are willing to consider for trial all bona fide new varieties.

RECENT POMOLOGICAL LITERATURE.

Cyclopedia of Hardy Fruits. U. P. Hedrick. The Macmillan Co. 27s.

Text Book of Pomology. T. H. Gourley. The Macmillan Co. 12s.

Fundamentals of Fruit Production. By V. R. Gardner, F. C. Bradford, H. D. Hooker, Jr. The McGraw Book Co. 22s. 6d.

Fruit Farming, Practical and Scientific. C. H. Hooper. Second Edition, revised and extended. The Lockwood Press. 6s.

THE list of books given above is a comment upon our native custom of leaving research to private enterprise. Three out of four of the writers are Americans and all occupying positions which enable them at once the opportunity for research and the time to present their conclusions in book form.

In England, we have, until a very recent date, left the literary instruction of fruit culture to the amateur or professional grower, and the result is that we have at present no modern works comparable with the three first named to the credit of a native author.

There is but little doubt that this reproach will be removed before long, thanks to a tardy Governmental recognition of the importance of Horticulture, but at the present moment we have to lean very largely upon the United States for exhaustive treatises upon Fruit Culture and research connected with it.

The *Cyclopedia of Hardy Fruits* by Prof. Hedrick may be best described to British readers as an American "Hogg." It describes with an admirable brevity those fruits which are, or are likely to be, of interest to the fruit grower in the States. A good feature of many American authors is the importance given to the habit of the fruits under discussion, their soil preferences, resistance to pests, etc. Prof. Hedrick is no exception to this admirable rule, and at the same time his descriptions of fruit and tree are adequate and illuminating. It may perhaps be said that he had not quite taken a firm seat either on the stool of exact botanical description or that of popular terminology, but all who have attempted such work will sympathise. It is extremely difficult to draw a line between the extremes of systematic description.

The British grower will turn with special interest to those American varieties of Apples which appear on our winter markets, and will probably wish to try their behaviour in this country.

A word of warning will perhaps save some disappointment. Most of the Apples which reach our shores are grown in a Continental climate, great summer heat and much sunshine, in fact a climate where the Peach and Vine ripen in the open. The American varieties that do best in this country, with but a few exceptions, are those from the Northern States, and even these fail to ripen

fully in a dull and cold summer. It is probable that America will not be able to help us much in our search for the ideal Apple.

But Prof. Hedrick's book deals with all hardy fruits, and while a few pomologists will pick a friendly bone or two with him here and there, the fruit grower will be rightly grateful for a body of valuable information brought together under one cover.

Professor Gardner and his colleagues touch on a very different aspect, and by summarising the research on fruit problems of the recent years have provided an invaluable work of reference for the expert and advanced student.

For many years research workers have wanted such a book to aid them in the hunt for elusive papers in Transactions, Proceedings, and Reports, innumerable, and their gratitude to the authors will, we fear, at first cloud their critical appreciation. It is in fact more than ordinarily difficult to criticise such a work. To sum up the results of research on a given subject, results written in many languages, experiments made under widely varying conditions, interpreted by individuals whose bias is often only to be guessed at, would seem a superhuman and even impossible task. But we are none the less thankful that an attempt has been made, and though we can but read the book in the light of our own prepossessions there are many points which will cause a "re-valuation of values," and bring us to that stocktaking which is so important an item in the mental balance sheet.

The author's treatment is to take a subject such as Water Relations and to give a chapter to its various aspects, such as Water Requirements, Nitrate and Utilization of Water, Excess and Deficiency of Water and its influence on the Plant, etc.

A large number of experiments on these subjects are brought together, and their general tendency indicated.

No one can read, for instance, this section of the water requirements of fruit trees and plants generally without giving fresh thought to the fundamental question. The section on the mutual influence of stock and scion will also be read with great interest, as will that on Pollination, but in both cases it will be felt that we cannot as yet see the problem as a whole, and much petrol will flow through the carburetters before we reach finality on these much discussed subjects.

Prof. Gardner's book is not light reading, its 686 pages will perhaps deter the dilletante reader, but for the serious student of Fruit culture it is, and will probably be for many years, an indispensable companion.

The *Text Book of Pomology* of T. H. Gourley is of similar nature and scope, but the presentation is less detailed. It is in fact a book which can be recommended to those who have already some knowledge of the subject practically, but wish to get a deeper insight into the reasons on which such

practice is based. The chapters include Bud Formation and Differentiation, and the factors which influence it, Pruning, Thinning, Climate and Pomology, Winter Injury, etc., and cover very nearly the subjects discussed at greater length by Gardner. A short chapter is given on the origin and improvement of Fruit, in which we miss the name of the Abbe Hardenpont, the pioneer of cross breeding fruit. We also note a statement that no Cherry has ever been known to give bud sports; a reference to back numbers of the *Revue Horticole* would have disproved this statement. This book can be thoroughly recommended as a step from the usual cultural work and the more scientific fundamentals of Gardner.

Our list concludes with the Symposium which Mr. Hooper has inaugurated, and as the first edition is probably well known to all our readers it is only necessary to say that the stiff covers of the second are appreciated, as is the enlarged treatment of many subjects. Mr. Hooper's book has many good points, not least being the cost of production given by different growers. As these are not revised to modern figures we assume the writer optimistically considers that the old rates will soon be reached again.

SILVER-LEAF DISEASE.—IV.

By F. T. BROOKS, M.A.
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AND
H. H. STOREY, B.A.

I. INTRODUCTION.

This Paper is an account of the results of investigations upon Silver-leaf disease since 1919, when the third instalment was published. These researches have been assisted financially by the Ministry of Agriculture and Fisheries, and have been carried out chiefly at Cambridge and at the John Innes Horticultural Institution, Merton. During the last two or three years some of the experimental work has been done at the East Malling Fruit Research Station, by the courtesy of Mr. R. G. Hatton, and at Heston, Middlesex, where Mr. W. J. Lobjoit kindly placed a considerable number of Victoria Plums at our disposal for experimental purposes.*

Since Brooks and Bailey wrote the paper "Silver-leaf Disease, III.," few papers on this malady have appeared, the most notable being those by Bintner (1) and Cunningham (9). Both of these papers are essentially confirmatory of the results published in the earlier reports of the present investigation, Cunningham's account dealing with the disease as it occurs in New Zealand. Bintner (1) attempts to draw a distinction between "true" Silver-leaf disease caused by *Stereum purpureum* and "false" Silver-leaf disease, due to physiological causes, but there are serious difficulties in this classification, as will be mentioned later.

Silver-leaf disease probably occurs to some extent wherever plums and apples are grown on a large scale. It is common in Holland and by no means rare in Denmark and other European countries. It is widespread in New Zealand (9), and is of frequent occurrence in South Africa, whence a culture of a fungus isolated from a silvered fruit tree upon being sent to us was identified as *Stereum purpureum*. Güssow (11) recorded the existence of this disease in Canada in 1912, and recently one of us has been informed that it commonly occurs in the Oregon apple-growing district. The difference in intensity of the disease in various parts of the world is partly due to varietal differences in the kinds of apples and plums grown, and also partly to climatic differences, the disease being at its worst in countries where the summers are relatively wet and the winters comparatively mild.

* For a short period Mr. W. Buddin (now of University College, Reading) assisted one of us in these investigations. His help is gratefully acknowledged.

II. FIELD OBSERVATIONS.

(1) *Hosts affected by silver-leaf disease.*

It is not proposed to give a complete list of new host plants seen to be affected since 1919; only those of special interest will be mentioned.

Silvered sucker shoots of elm connected with old stumps have been twice seen, also silvered hawthorn shoots. A Plant of *Rosa sericea*, var. *Pterocantha*, was killed by *Stereum purpureum* in the Cambridge Botanic Gardens in 1920, but it is not known whether the foliage was silvered before death. Mr. R. G. Hatton informs us that a plant of *Rosa rugosa* which appeared sickly during the summer of 1922 and was perhaps silvered, died at the end of the year and produced abundant fruit-bodies of *Stereum purpureum*, by which doubtless it had been killed. It is regrettable to have to announce this attack on roses, but with so many plants in the same family liable to succumb to the fungus, it does not seem surprising that roses also should occasionally fall a prey to it. As reported in an earlier paper (2) we have again seen examples of beech and birch trees killed by *Stereum purpureum* without the symptoms of silvering being manifest.

Since paper III. of this series appeared, two silvered pear trees have been seen. One was a Beurre Hardy pear, which had been unsuccessfully regrafted, the other was one of the Conference variety. A silvered stool bed of Portugal quince has also been seen. It seems unlikely that pear trees will become at all susceptible to silver-leaf disease for innumerable inoculations of different varieties have been performed, all of which have been unsuccessful. In these experiments the fungus spread only to a limited extent in the tissues and then quickly perished.

Serious cases of infestation of sweet cherries have not been encountered, but silver-leaf disease is often important in Morello cherries, where the symptoms and course of the malady are the same as in Victoria plums.

Peach trees are often liable to serious attack, and in the Worthing district where peaches are grown on a large scale under glass, this is perhaps the most serious trouble the grower has to contend with. The physical conditions of a peach-house are ideal for the development of silver-leaf disease if precautions are not taken to prevent infection by *Stereum purpureum*. Until recently no such precautions were taken, and several growers appeared to be unaware of the nature of the disease, one even allowing a dead plum tree covered with the fungus to remain just outside the door of one of the glass-houses. Here also the course of the disease is essentially the same as in plums, the wounds made in pruning the trees affording means of entry for the fungus.

In recent years two varieties of apples have shown special susceptibility to silver-leaf disease, and under certain conditions appear as liable to attack as is the Victoria plum. These are Newton Wonder and Early Victoria (often called Emneth Early in the Wisbech district). In these varieties the disease is often rapidly fatal. The varieties Lord Grosvenor, Grenadier, Lord Suffield, Blenheim Orange and Bramley's Seedling are moderately susceptible, but there is usually a prolonged struggle between host and parasite, and with Bramley's Seedling complete recovery is likely. Apples such as Lane's Prince Albert, Worcester Pearmain and Cox's Orange Pippin are only occasionally affected.

Earlier papers have discussed the susceptibility of different varieties of plums, the most resistant being Pershore, Early Rivers, and Greengage, although even these are occasionally attacked. In 1919 (3) it was reported that it was easy to induce silvering in Pershore plums by inoculation with *Stereum purpureum*, but such trees almost invariably recover, the reasons for which will be discussed later. One or two severe attacks of Monarch plums have been noticed where the trees had been somewhat drastically cut, but this variety, together with Pond's Seedling, Belle de Louvain, Transparent Gage, etc., is tolerably resistant.

(2) *Relation of previous treatment to severe outbreaks of silver-leaf disease.*

Neglect of silver-leaf disease is now comparatively rare in the fruit-growing districts of this country and consequently widespread attacks are less frequently seen than hitherto. In recent years epidemic occurrences of the disease have been usually associated with some previous inadvertent error in the treatment of the trees, which has resulted in innumerable exposures liable to invasion by *Stereum purpureum*. A few such examples will be described. After the war, tractors were introduced into many fruit plantations, and in apple orchards the lower branches of the trees were frequently cut away to facilitate cultivation. In the course of a year or two, several plantations of susceptible varieties such as Early Victoria and Newton Wonder became almost universally affected by the disease, it being clear that the fungus had entered through the exposures left unprotected after removal of the lower branches. In one plantation more than 1,000 Early Victoria trees became silvered after such treatment, many of which were killed outright. In another area, old Bramley's Seedling trees had been similarly treated, with the result that many became silvered although the disease did not make such rapid progress as with the other varieties mentioned.

Another operation which not infrequently results in silver-leaf disease is the re-grafting of apple trees, and several examples of veritable epidemics caused thereby have been seen. With susceptible varieties such as Newton Wonder, the risk of infection in re-grafting is very great as the following example shows. In November, 1920, 150 Newton Wonder trees, nine to ten years old, were cut

back and were re-grafted with Bramley Seedling scions in March, 1921. In the following August silvering began to appear and the disease spread so rapidly and universally that practically every tree was killed during the next winter. In this case Stockholm tar was applied to the cut extremities, but, as will be seen later, this substance is a very imperfect protection. Where "pug"—a mixture of clay and cow dung, has been used in re-grafting, the losses have been far less severe.

If susceptible varieties of plums are drastically pruned or thinned there is similar danger of infection. For instance, Czar plum trees badly affected by *Monilia cinerea* (brown rot) in 1920 were drastically cut during the winter of 1920-21 to remove diseased branches, with the result that the following summer most of the trees were severely attacked by silver-leaf disease. Other Czar trees from which the branches killed by *Monilia cinerea* had not been removed, remained free from silver-leaf disease.

In nurseries also there is sometimes a considerable incidence of this disease, particularly in plums, which is associated with certain operations carried out in the routine of propagation. Plums are usually budded on to a stock and when the bud proliferates in the spring, the stock is cut back to form a stub two or three inches long to which the developing shoot is tied, thus obviating the necessity of staking. The stub is finally cut away during the autumn or winter. In this practice two opportunities are afforded for the entry of *Stereum purpureum*, one at the time when the stock is cut back, and another when the stub is removed. During the last three years numerous instances of infection where one or other of these exposed surfaces has not been protected have come to our notice. From the periods at which cutting of this kind is done, infection will often not result in silvering until the second year's growth of the bud.

(3) *Stock influence.*

It was pointed out in 1919 (3) that young Victoria plum trees worked on Pershore stocks were as readily infected artificially with *Stereum purpureum* as those worked upon other stocks which are commonly used. As will be shown later, the chief varieties of plum stocks are susceptible to silver-leaf disease when deliberately inoculated, but notwithstanding this, observation in the field indicates that the nature of the stock may indirectly influence the relative susceptibility of such a variety as Victoria. For example, in an East Anglian fruit plantation Victoria plums about twenty-two years old showed a striking difference in susceptibility according as to whether the tree was worked on the Myrobolan or the Common Plum stock. Where the latter had been used, the habit of the trees was more open, with shorter lateral growth and apparently harder wood than usual in this variety; correlated with these changes there was a marked reduction in the disease. An additional factor must, however,

be taken into consideration here as the Common Plum stock had been worked at the height of two or three feet, so that a considerable portion of the trunk of the tree belonged to the stock, whereas with the Myrobolan stock the trees had been worked in the usual way. Whatever be the explanation, there is no doubt about the profound change in habit which the Common Plum stock had induced in this plantation, and the observation gives rise to the hope that means may be found to check somewhat the exuberant growth of the variety Victoria and thereby render it less liable to the broken limbs which are one of the commonest sources of infection. With the assistance of Mr. R. G. Hatton, of the East Malling Research Station, the possibilities of improvement in this direction are being explored, but from the nature of the work, it will be a long time before it can be ascertained whether success is likely to be achieved.

III. THE SUSCEPTIBILITY OF PLUM STOCKS TO SILVER-LEAF DISEASE.

As a preliminary to other enquiries it was thought desirable to test the susceptibility of different kinds of plum stocks by artificially inoculating them with *Stereum purpureum*. The stocks used for this purpose were two to three years old and the test was applied in the following ways :—

(*a*) The main stem was inoculated with a small portion of a sporophore of *Stereum purpureum*.

(*b*) The stock was grafted with a scion of a Victoria plum which had been deliberately infected some time previously with *Stereum purpureum*, with a view to ascertaining whether the fungus would readily pass from the scion into the stock.

The following stocks were experimented with in this fashion : Black Damask D, St. Julien D, Myrobolan B, Common Plum, Common Mussel, Broad Leaved Shiny Mussel, Brompton, Pershore and Brussels.

Not a single one of these stocks proved immune to invasion by *Stereum purpureum* in both these ways. Where the inoculation was carried out by inserting the fungus in the main stem of the stock, the number of successes was always lower than when such varieties as Victoria or Czar were inoculated in the same manner, but about fifty per cent. of the inoculations on the following stocks resulted in silver-leaf : Black Damask D, St. Julien D, Common Plum, Broad Leaved Shiny Mussel, Brompton, Pershore and Brussels. In Myrobolan B, however, of eight inoculations of this kind none were successful, and in Common Mussel only one of eight inoculations caused silvering. Where infected Victoria scions were worked on these stocks invasion was much more certain, and, with one exception, of four of each of these worked stocks, all became

invaded by the fungus, many being killed outright by it with fructifications of *Stereum purpureum* appearing at soil level. It is clear that if sufficient opportunity be afforded, all the above stocks can be invaded by this fungus. This is not surprising when it is borne in mind what very diverse kinds of plants can be killed by *Stereum purpureum* if it reaches the internal tissues. It may be urged with some reason that susceptibility to artificial inoculation may be no criterion of natural suceptibility, but experience has shown that there is usually a correlation between the two. After the critical nursery phase there is little opportunity for the stock to be infected except through the variety which has been worked upon it. In spite of the above results, we are of the opinion that by careful attention to the stock and the manner of working it, a harder type of growth, less susceptible to silver-leaf disease, in some of the chief commercial varieties of plums, may perhaps be induced.

IV. PATHOGENICITY OF DIFFERENT STRAINS OF *STEREUM PURPUREUM*.

In 1913 (2) and again in 1919 (3) it was pointed out that *Stereum purpureum* obtained from a saprophytic source was just as capable of causing silver-leaf disease as the fungus obtained from an affected plum tree. Additional experiments have confirmed the truth of this statement. For instance, the fungus taken from dead poplar stumps both in Kent and in Denmark have readily induced silver-leaf disease in plums. Hence from the pathogenic standpoint, *Stereum purpureum*, on whatever substratum it may be found, must be looked upon as a facultative parasite.

As is well known, the fructifications of this fungus are exceedingly variable in form and to some extent in colour. Minute microscopic differences also are to be found in various collections of the fungus, but from the pathogenic standpoint these structural differences are immaterial. Mr. E. S. Salmon sent us material of *Stereum purpureum*, variety *atromarginata*, some time ago and this was found to be readily capable of inducing silver-leaf disease. Recently Burt (7) in America has distinguished under the name *Stereum rugosiusculum* Berk. and Curt, the forms bearing hymenial cystidia from *Stereum purpureum* (Pers.), Fr., but in our experience this separation appears doubtfully valid. Numerous collections of the fungus from different substrata have been examined, and, as pointed out by one of us elsewhere (6), there seems to be every possible intergrade between forms possessing many hymenial cystidia and forms devoid of them. Forms which would be included under the name *Stereum rugosiusculum* by Burt have as readily induced silver-leaf disease as *S. purpureum* in the narrow sense. We consider that there is no real distinction between these forms and that it is best to use only the species name, *purpureum*.

This fungus will grow saprophytically or semi-parasitically upon almost any kind of dicotyledonous woody material in temperate regions, as long as the tissues are moribund or have only recently died. In nature it does not often occur upon tree stumps and logs after invasion by other fungi. Upon such material it is either the first micro-organism to develop, or it is not likely to occur thereon at all. This mode of life is intimately associated with its pathogenic proclivities. This species is of common occurrence upon stumps of all kinds of broad-leaved trees, except oak, upon which it scarcely ever occurs, perhaps because *Stereum hirsutum* almost invariably begins to develop upon this at an early stage. Until recently it was thought not to occur upon coniferous wood, but Mr. Oldham, of the Ministry of Agriculture, has reported it on larch stumps and one of the writers has seen it growing profusely upon pine logs.

V. THE EFFECT OF *STEREUM PURPUREUM* UPON INVADED TISSUES.

The presence of *Stereum purpureum* in the woody parts of such hosts as plum and apple causes a well-marked browning of the tissues, owing to the accumulation therein of gummy substances produced indirectly by the action of the fungus. It has already been pointed out (2) that a branch in the early stage of attack has only a sector of the wood invaded, but ultimately the whole of the tissues become permeated by the fungus, when the branch dies and the parasite produces its fructifications during wet weather. It is characteristic of this disease for the leaves of such a branch in lateral proximity to the discoloured wood or above it to assume a silvery appearance owing to the excretion by the fungus into the transpiration current of some substance which indirectly brings about this change in the foliage. From inoculations of straight branches of plum trees in the dormant season it seems clear that the wood discoloured by the fungus is no longer functional in carrying the water stream, for buds actually on the line of advance of the fungus fail to open and rapidly collapse owing to the cutting off of the water supply. Buds laterally just outside the invaded tissues expand and usually give rise to silvered foliage, as do those some distance above the discoloured wood, even though in the same vertical plane, owing to lateral diffusion from the uninvaded tissues. Buds which are remote from the discoloured wood give rise to healthy foliage. In some recent inoculation experiments it has become apparent that the influence of the substance secreted by the fungus is felt sometimes *below* the discoloured wood as well as above it. In one tree silvered foliage appeared nine inches below the lowest tissues actually invaded by the fungus. The substances secreted by the fungus therefore pass to a limited extent downwards as well as upwards. This is due either to static diffusion or to a distinct downward flow in the vessels at certain times, as

suggested by Dixon (10). In this connection it may be pointed out that in some injection experiments with dyes, trees injected with eosin six inches above soil level in March were found permeated by the dye practically to the extremities of the roots when the tree was cut up in August. It is difficult to understand the conveyance of the dye to the ends of the roots solely by static diffusion but it is readily explicable on the assumption of a downward flow.

It has already been stated that the discolouration of plum and apple tissues invaded by the fungus is due to the accumulation of gum-like substances. Where a fungus invading woody tissues does not cause delignification, the occurrence of such gummy residues is one of the most wide-spread pathogenic phenomena. Different views have been expressed as to the origin of gum in the tissues of species of *Prunus*, which is sometimes a pathological phenomena not associated with parasitic invasion. Prillieux (13), Brooks and Bartlett (4) and others believe that starch or other living cell contents play an important part in gum formation, while Butler (8) holds that the gum is formed by hydrolysis of the walls of embryonic wood cells owing to abnormal excitation of the cambium. This divergence of opinion may partly be due to the fact that gum formation in the genus *Prunus* probably includes many processes which have not been separated clearly from one another. Gum formation in old woody tissues differs vastly from the degeneration of newly-formed wood cells into gum pockets as described by Butler (8). In fully-developed woody tissues discoloured by the action of *Stereum purpureum* gum is present both in the vessels and in the ray cells. In our opinion such gum is formed chiefly in the living cells, whence it passes into the vessels and is produced mainly from starch as a reaction to the presence of the fungus. In support of this statement it has been found that gum formation is most copious when the starch content of the wood is greatest ; for instance, the cut extremities of plum twigs kept in the laboratory produce large quantities of gum during the winter, but when the buds expand gum formation is much less. In these old tissues invaded by *Stereum purpureum* there is no indication of gum formation through the degeneration of the cell walls. As stated in the literature on the subject, gum formation frequently occurs in response to other kinds of injury besides parasitic invasion. In our work profuse gumming has occurred where plum trees have been injected with certain dyes such as gentian violet. Here gum formation was induced owing to the presence of minute quantities of a toxic substance, but where a more powerful poison was employed such as sodium arsenate, the tree was killed without gum being exuded.

There appear to be two kinds of gum formed in plum wood attacked by *Stereum purpureum*. One is a practically colourless substance except when seen in dense masses, which is soluble in warm water and readily stains with Delafield's hæmatoxylin ; this gum corresponds to that which often exudes from plum trees. The other type of gum found in invaded wood is yellow-brown,

insoluble in hot water, and does not stain with Delafield's hæmatoxylin. The first form is readily penetrated by the hyphæ and in fact can be used as a culture medium for the fungus, while the second type of gum is usually not penetrable by the fungus.

VI. NATURAL RECOVERY FROM SILVER-LEAF DISEASE.

The occasional recovery of silvered fruit trees without treatment is a well-known phenomenon, although it is frequently ignored by persons who claim to have discovered a cure after treating a few diseased trees. With a fungus inhabiting the woody parts of a tree it is clear that if its progress in those tissues be stayed, the symptoms of disease will disappear in time on account of the cessation of influence by the fungus and the formation of new healthy wood. Under these conditions the fungus is left isolated in the wood already discoloured, and it is only a question of time before it dies. As with other diseases of a parasitic nature, a continual struggle proceeds between host and parasite, and although in silver-leaf disease the fungus usually gains the victory over certain varieties of plums and apples, it by no means always achieves this. The struggle proceeding between host and parasite in woody tissues is probably of a different nature from that which takes place in a leaf attacked by a parasite ; for in plum wood most of the cells, e.g., the vessels and fibres, are dead and cannot react protoplasmically to the hyphæ. On the other hand, the medullary ray cells remain alive until the wood is several years old and can react forcibly to the parasite. The vessels are the chief elements of the wood invaded by *Stereum purpureum* and although dead they may exert a strong passive influence on the fungus according to their relative frequency, distribution and aeration.

On several occasions it has been noticed that natural recovery from the disease has been most pronounced after a hot, dry summer. For instance, after the drought of 1921 the recovery of Victoria and Czar plums was very pronounced and in our experimental area, where trees had become silvered through inoculation, fifteen to twenty per cent. of the trees of these varieties completely recovered. It is not yet known in what precise way weather conditions influence the rate of recovery.

Pershore plums, which readily develop silvery symptoms the first season after inoculation, almost invariably recover later. Upon examination, Pershore and Victoria trees which have recovered and pear trees which have been unsuccessfully inoculated, all show the same kind of reaction in the tissues. Where the fungus has spread appreciably in the wood there is the usual kind of discolouration due to the type of gum which is pale in colour and takes up Delafield's hæmatoxylin stain, but on the periphery is a narrow, much darker zone, containing gum of the other kind previously mentioned which does not

become stained with hæmatoxylin. Sections through the invaded tissues show hyphæ, apparently dead, in the lighter discoloured zone, but not in the darker, peripheral region which has apparently formed an impenetrable barrier to the fungus. All attempts to isolate and grow the fungus from the central region failed; doubtless the fungus was dead. It is not known how the darker gum in the outer zone is formed, although it is perhaps produced by a change in the other kind of gum, but it is undoubtedly a factor of great importance in checking the further development of the fungus and in bringing about recovery from the disease. With the formation of a barrier of this nature, the victory of the host is complete and the diseased tissues are isolated like an island. One of the differences between the Pershore and the Victoria varieties of plum lies in the more ready formation of this gum-barrier in the former, and with this is associated to a great extent the greater resistance of the Pershore variety to silver-leaf disease. In our inoculations of pear trees—and they have all hitherto been unsuccessful, the formation of the gum barrier has occurred almost immediately after inoculation, so that the fungus has spread very little in the tissues, thus explaining the almost complete immunity of this kind of fruit tree to silver-leaf disease.

VII. MODE OF NATURAL INFECTION BY *STEREUM PURPUREUM*.

Successful infection of plum trees in the field by spores of *Stereum purpureum*, resulting in silvered foliage, have previously been recorded (2, 3), but much more detailed information was required as to the way in which this fungus acts as a wound parasite. For instance, it was not known whether *S. purpureum* was more likely to invade freshly exposed tissues or woody parts that had been open to the weather and possibly already invaded by other micro-organisms; nor had it been ascertained whether the fungus could cause infection to an equal extent at all times of the year, or whether there was some special season of the year during which the fungus was most dangerous. Attention has recently been concentrated upon this part of the silver-leaf problem, for fuller knowledge of these aspects of the biology of *S. purpureum* is fundamental to any further elucidation of the disease.

It was decided therefore to carry out certain experiments on infection by *S. purpureum* under controlled laboratory conditions, to be followed as far as possible by comparable experiments in the field. For this purpose branches of Victoria or Czar plums, three to six years' old, were brought into the laboratory, placed in water, and their upper extremities—either freshly cut or after exposure to the atmosphere for some time, covered with a spore emulsion of *S. purpureum*, in order to ascertain whether infection could be brought about in this way. At first the extremities inoculated immediately after exposure were kept in a moist

atmosphere for several days by covering them with glass tubes containing moist cotton wool, but it was soon found that such protection did not materially affect the result. The first experiment of this kind was performed in February, 1922, and Victoria plum shoots eight inches long became completely permeated by the fungus in two months, whether the inoculated extremity had been kept in a humid atmosphere for many days or only for two days. Subsequent experiments showed that the provision of a saturated atmosphere even for a short period was unnecessary, and later experiments have been performed by leaving the inoculated extremities exposed to the atmosphere. In these earlier experiments several shoots which had been completely invaded by the mycelium—as shown by sections, developed fructifications of *S. purpureum* at the level of the water. Two conclusions were to be drawn from these experiments :

(1) That under laboratory conditions spores of *Stereum purpureum* could infect living plum wood and that the mycelium arising therefrom rapidly permeated the wood.

(2) That a very humid atmosphere was unnecessary for infection.

It may be added that control experiments sometimes became contaminated by moulds, especially where the twigs were covered by glass tubes for many days, but the amount of discolouration below the exposed surface was infinitesimal in comparison with twigs invaded by *S. purpureum.*

The next experiment was to compare the rate of invasion of living and dead (autoclaved) plum twigs. Here the autoclaved shoots showed little penetration by *S. purpureum* and were often badly contaminated with moulds, whereas the living twigs became rapidly permeated as before. This result suggested that *S. purpureum* may more readily invade healthy wood than tissues which have been already killed by some other means.

Another experiment of a similar kind carried out in May, 1922 was framed to test the influence of the age of the wood upon liability to infection by *S. purpureum.* For this purpose Victoria twigs, one year old, two years old, and three years old, were simultaneously inoculated with a spore emulsion. After an interval they were all found to be similarly invaded. The possibility of the third year wood being invaded from infected first year wood can be excluded, because the discolouration in the oldest wood was as extensive as that in the youngest wood and also because the lateral spread of the mycelium in such tissues is only slight. Plum wood retains its medullary ray cells in a living condition for a number of years, and it is probably that all such wood containing living cells is liable to invasion by this fungus. These results agree with certain field observations in which silver-leaf disease has appeared in connection with pruning one year old shoots as well as after cutting back older twigs. On the other hand wood quite recently formed from the cambium does appear to

resist invasion by the fungus from older wood, as has been pointed out in an earlier paper (2).

In the next experiment, carried out in June, 1922, the twigs inoculated as before were exposed to outdoor conditions : (*a*) in intense insolation, (*b*) in shade, inoculated controls being kept at the same time in the laboratory, and uninoculated controls in all three places. Within three weeks all the inoculated shoots, whether kept in the sun, shade or in the laboratory, were infected to the extent of several inches, while only one of the uninoculated controls showed discolouration of more than a millimetre below the exposed surface, this exceptional twig having been casually invaded by some unknown fungus. Hence infection of such shoots by *Stereum purpureum* can proceed even where the tissues are exposed to direct insolation.

Having elaborated a technique for the study of invasion by *Stereum purpureum*, the experiments are being continued month by month to ascertain whether the condition of the wood is a factor of importance, and to determine whether infection of exposed surfaces on trees *in situ*, takes place in the same way as in cut shoots. As far as these experiments have proceeded, infection appears to take place on the trees as in the experiments described above. It is safe to conclude that *Stereum purpureum* is able to infect freshly exposed plum wood, including wood only one year old, and that under suitable conditions invasion is very rapid. It is also probably true that this fungus infects fresh wood more readily than wood which has already been killed, e.g., by the action of other micro-organisms.

While the above experiments were being carried out, other experiments, of a less carefully controlled nature, were also being performed in the field, partly with the view to ascertaining whether any particular type of wound was specially liable to invasion and partly again to determine the relationship of length of exposure of the wound to risk of infection. In the experiment on the determination of the optimum period of exposure of a wound for infection, branches were sawn off Victoria and Czar plum trees close to a side branch and an emulsion of spores was applied either directly or at certain intervals up to eight months after the wound had been made. Of a large number of inoculations (usually about seventeen for each interval) none resulted in silvering of the foliage except those carried out immediately upon or soon after exposure. Thus seven out of seventeen inoculations made at once after wounding in January were successful, one was successful (out of seventeen) after two weeks, and one was successful (out of seventeen) after a month's exposure. This result is in agreement with those described above, in which it seems clear that freshly exposed wood is most liable to invasion.

In another large field experiment an attempt was made to ascertain whether any special type of wound was particularly liable to infection. For

this purpose three types of wounds were used : (*a*) where the exposure was trimmed close to a living branch and made smooth with a knife ; (*b*) snags left rough as cut with a saw ; (*c*) branches split away at a fork or at the junction with the trunk. Spores in an emulsion were applied immediately after the exposures were made (October, 1921) and at intervals throughout the winter until the end of March (1922). All three types of wounds were found liable to infection, as shown by the development of silvered foliage, but snags and split branches gave a higher percentage of positive results than where the exposures were trimmed close to the stems. In addition, wounds in three and four year old branches were infected more frequently than in two and one year old shoots. It is clear therefore that any fresh exposure of wood is liable to attack, but that some types of wounds, e.g., snags and split branches are probably more dangerous than others.

As has long been known, the hyphæ of *Stereum purpureum* are not to be found in the silvered leaves, the pathological symptoms therein being produced by the fungus some distance below in the stem. In 1919 Bintner (1) stated that injured leaves of the Portugal laurel could be invaded to a slight extent by the fungus. We can confirm this statement. If the upper surface of leaves of the Portugal and Cherry laurel be injured and spores or mycelium of *Stereum purpureum* be placed on such a wound, the fungus develops in the immediate vicinity of the injury, killing the cells centrifugally and causing a brown spot to appear. The fungus does not proceed far, however, because the invaded tissues are soon cut off from the healthy parts of the leaf by a cork layer, with the result that the killed portion falls away, causing a " shot-hole " effect. In such experiments the hyphæ kill the leaf cells directly without inducing preliminary symptoms of silvering.

In connection with the investigation of the mode of natural infection by *Stereum purpureum,* some consideration has been paid to the general nature of the micro-organisms which invade the pruning wounds of plum trees. When branches are cut away or are shortened, the exposed extremities soon become invaded by bacteria and fungi unless covered by an impervious antiseptic. These invading organisms invariably cause a dark discoloration of the wood, which often extends far into the tissues below. If the invader be a dangerous type, e.g., *Stereum purpureum,* disease will be established ; if on the other hand the organism be relatively innocuous it will continue to exist passively in the discoloured parts, surrounded by healthy tissues, until it dies. A preliminary survey of the diversity of forms which enter these pruning wounds has been made. For this purpose sections of the discoloured tissues were cut near the junction of healthy and diseased wood, and were placed in plum wood agar in Petri dishes. After a few days the organism or organisms present in the wood grew out into the medium whence they could be transferred to other media for

systematic determination. It was usually found that only one type of organism grew out from any one set of sections. Fungi were of more frequent occurrence than bacteria below these wounds, and it was concluded that practically all the discoloration below these exposures was due to organisms of this class. Many different fungi were found in these regions, including *Stereum purpureum*, *Fomes pomaceus*, many pycnidial forms, and several Hyphomycetes, including *Alternaria sp.* Many of these organisms are harmless, and it seems to be entirely fortuitous which of them becomes established. At the outset of invasion several different forms probably compete with one another, but sooner or later one of them grows into the tissues faster than the others. There may also be a succession of fungi following one another in these discoloured tissues. The rate of invasion of pruning wounds by these micro-organisms varies greatly at different times of the year ; in the winter invasion is slow and often practically negligible, but in summer it is relatively fast. This does not imply that infection is not begun during the winter for undoubtedly it is often so effected, but it means that the rate of growth of these organisms is much more rapid at high temperatures than at low ones.

VIII. WOUND PROTECTION IN FRUIT TREES.

It has long been urged that the wounds caused in thinning and pruning should be covered with some protective substance to prevent invasion by micro-organisms, especially by such dangerous fungi as *Stereum purpureum*, although there has been much uncertainty as to the efficacy of the different substances used for this purpose. It is sometimes stated that there is a natural means of protection of such wounds in arborescent plants by the formation of a callus. This view is, however, erroneous, especially with fruit trees. Callus tissues are slow in formation and in plum and apple trees it is only exposures of tissues three to six years old that certainly become completely covered with the lapse of time ; meanwhile the woody parts are unprotected from risk of invasion except for the formation of gum as a wound response, which is only a partial protection against infection. Exposed tissues of greater age are rarely completely covered by callus. Hence from the practical standpoint callus formation is only of limited importance as a protective factor.

A substance placed over a wound to protect it from pathogenic invasion may serve this purpose in two ways ; it may form a cover which cannot be penetrated by micro-organisms, or it may be permeable to fungi and bacteria, but owing to high toxicity it kills these before they have proceeded far. Many substances, e.g., certain kinds of paints, perform both functions. Some of these bodies crack after drying and exposure to the atmosphere with the result that channels are opened into the tissues which if not impregnated by an antiseptic

will thereby become invaded. Again, these protective substances are often cracked by the growth of the tissues below and this may result in exposure. From these considerations it will be seen how important it is to make at least two and preferably several applications of these protective substances at intervals of about three months. It has been shown earlier in this paper that exposures in one year old plum twigs are liable to infection by *Stereum purpureum*, although less so than older tissues. Apart from nursery stock, however, it is entirely impracticable to treat exposures in young twigs with a protective substance. Long observation has shown that it is the exposures in older tissues from three years upwards that are most liable to infection by *Stereum purpureum*, and these undoubtedly should be protected immediately after exposure. If there is delay before the substance is applied, micro-oganisms may have already invaded the tissues to such an extent that any toxic ingredients in the protective substance will not reach them.

An attempt has been made to gauge the efficacy of these protective substances by determining the rate and cause of the discolouration of the tissues below the exposures. For this purpose wounds of different kinds were made, e.g., snags and branch extremities flush with vigorous older branches, and were immediately covered with one of the following substances : gas tar, Stockholm tar, white paint, antifouling paint (used on ships' bottoms), and gentian violet (in concentrated aqueous solution), the last named being used as it is highly toxic to *Stereum purpureum* in cultures. Unprotected control wounds were also kept under observation, and the experiments were repeated at different times of the year. After certain periods the portions of the trees bearing the wounds were cut away and the wounds examined, the presence or absence of micro-oganisms near the limit of discolouration, and as far as possible their nature, being determined. These experiments are not yet complete but a statement of the results to date may be made. It was soon found that snags frequently die without invasion by micro-organisms owing to diversion of the transpiration current, so chief consideration has been given to the types of wounds where parasitic invasion is alone the cause of death of the tissues. A noteworthy feature of these results is that the rate of discolouration below the exposure is much greater in summer than in winter ; in fact in the latter season it is insignificant. This does not mean that wounds arising in the autumn or winter can be ignored, because the dangerous initiation of invasion may have already begun which will proceed with vigour when the temperature rises.

Of the substances used, gas tar and antifouling paint have been most effective in preventing or delaying invasion by micro-organisms. Gas tar has had no appreciable adverse effect upon the tissues when carefully applied. Antifouling paint has unfortunately sometimes killed considerable areas of bark around wounds dressed with it, but it is hoped that arrangements can be made to reduce

its toxicity to host tissues. This paint solidifies homogeneously and is little liable to cracking, but as sold at present it usually requires thickening for most effective use. Stockholm tar has been very disappointing, and both in these experiments and in certain field trials on a large scale it has been found practically useless as a means of protecting tree wounds against fungal attack. Its toxic constituents are probably easily removed by rain. White paint is a fair protection, but although not so good as antifouling paint is less toxic to host tissues than the latter. Gentian violet is only effective for a short time. One other substance, surgical tape, has been tried as a wound cover at the suggestion of Professor Barker. In our preliminary experiments surgical tape has not given particularly good results and for the type of wounds employed has been difficult to apply.

With wounds such as those described, most protective substances will crack in the course of time, hence the necessity for renewal of the dressing. As *Stereum purpureum* most readily invades newly-exposed wood the risk of invasion by it at a later stage when perhaps the protective cover cracks may be considerably reduced. There is also reason to believe that if certain other fungi first invade the exposed tissues, the way is thereby barred for *Stereum purpureum*.

IX. PHYSIOLOGY OF *STEREUM PURPUREUM*.

1. *Longevity of spores.*

The spores of this fungus are small and thin-walled, but nevertheless retain their vitality for considerable periods under certain conditions. For instance, kept at a temperature of 15°-20°C in a laboratory atmosphere of normal humidity, some spores were germinable after fifty-five days, although none survived a period of sixty days. When kept part of this time in a very humid atmosphere about 1 per cent. retained their vitality more than sixty days, but spores deposited at the same time and subjected to extreme desiccation were all dead in two days. At 24°C spores kept in a relatively dry atmosphere ceased to germinate after twelve days. It seems therefore that a high degree of desiccation is more inimical to retention of vitality than moderate fluctuations of temperature.

2. *Optimum temperature for growth.*

Preliminary tests indicate that on artificial media in Petri dishes growth is best at a temperature round about 30°C.

3. *Toxicity of various substances to Stereum purpureum.*

In connection with further enquiries as to the possibility of curing silver-leaf disease by injection (cf. Silver-leaf Disease III.), a large number of tests have been made to determine the toxicity of various substances to *Stereum*

purpureum in a liquid medium. In recent years much work has been done by Humphrey and Flemming (12) in America to determine the relative toxicity of various chemicals to certain fungi, and Miss Rumbold (14) has investigated the toxic effect of dyes and other substances on chestnut trees.

Our experiments were designed to find out the inhibiting concentration of certain antiseptics to further growth of *Stereum purpureum* when introduced into a liquid medium on small fragments of agar. Dox's medium containing 15 or 10 grams of sugar per litre was chosen for these tests and the method of determining the inhibiting concentration of the toxic ingredient was as follows:—

(1) Tubes were prepared containing 5 cc. of Dox's medium at double strength. These were sterilised by intermittent steaming.

(2) A " dilution " series of tubes was prepared of the toxic substance with distilled water. These tubes were sterilised by steam.

(3) Subsequently the contents of a tube of culture medium and a tube containing the toxic substance were mixed by pouring one to the other several times, the resulting mixture being divided between the two tubes. This process of mixing was carried out without appreciable risk of contamination, only one tube in 600 being spoilt in this way.

The following is a list of minimum concentrations of various substances found to inhibit further growth of *Stereum purpureum* :—

Gentian Violet (Gürr)	about	0.02	per cent.
Methyl Violet 5B (Grübler)	,,	0.003	,,
Methyl Violet 6B (Gürr)	,,	0.002	,,
Brilliant Green (Gürr)	,,	0.008	,,
Bismarck Brown	,,	0.04	,,
Congo Red	,,	0.4	,,
Trypan Blue	,,	0.4	,,
Methylene Blue—med. pur. (Grübler)	,,	0.03	,,
Erythrosin	,,	0.2	,,
Eosin	,,	1.0	,,
Phenol	,,	0.08	,,
Sod. phenol sulphonate	,,	0.4	,,
Sod. dinitrobenzene sulphonate	,,	0.15	,,
Sod. alizarin sulphonate	,,	0.005	,,
Potassium fluoride	,,	0.3	,,
Potassium oxalate	,,	1.0	,,
Sod. arsenate	,,	1.0	,,
Borax	,,	0.2	,,
Dimol	,,	0.013	,,
Superol	,,	0.00003	,,

Dimol is an intestinal disinfectant and superol is a proprietary antiseptic frequently used to prevent mould growths upon raw rubber in the Eastern tropics. Superol is by far the most toxic to *Stereum purpureum* of all the substances used, and it is also highly inimical to the growth of other fungi such as *Botrytis cinerea*, *Penicillium expansum*, and *Fusarium coeruleum*. On the other hand, superol appears to be less toxic to the higher plants, e.g., plum shoots, than such a substance as gentian violet.

X. PHYSIOLOGY OF SILVERED LEAVES.

Some work of a preliminary kind has been done upon the photosynthetic activity of silvered leaves, the results of which indicate that the symptoms of silvering result in considerable disturbance from the normal. If Sach's test be applied to moderately silvered and healthy plum leaves at the end of a day of bright sunlight, the silvered leaves are usually found to contain more starch than the healthy ones. In this connection it must be pointed out that translocation of carbohydrates from the lamina is slower in a silvered than in a healthy leaf ; in fact in a heavily silvered leaf some of the starch in certain areas seems irremovable however long the leaf be kept in darkness. A part therefore of the greater starch content of a silvered leaf may be due to a decrease in the rate of translocation. An attempt has been made by Mr. Inamdar to compare directly the rate of carbon-assimilation of moderately silvered Victoria plum leaves with healthy ones, using the apparatus employed by Dr. F. F. Blackman in his work on photosynthesis. Mr. Inamdar found that a moderately silvered leaf assimilated less actively than a healthy leaf, but still at a fair rate. It would appear that the usually greater starch content of silvered leaves is due to a diminished rate of translocation rather than to increased photosynthetic power.

Another characteristic of silvered foliage is that it wilts before healthy foliage. The more heavily silvered are the leaves the quicker do they wilt when the branch bearing them is cut from the tree and placed in water. Thus in one experiment a moderately silvered plum shoot was somewhat wilted two days after being placed in water in the laboratory, a badly silvered shoot was quite wilted, while the leaves of a healthy shoot were still fully turgid. The cause of this more rapid wilting of silvered foliage is not clear, but there is some evidence that the stomata of silvered leaves have partly lost their power of adjustability so that they remain wide open for longer periods than do healthy stomata. On the other hand the early wilting of silvered leaves may be due to a more general physiological disturbance of the tissues through which the transpiration current passes.

It may be mentioned that there is no heredity transmission of silver-leaf disease, for seeds of a silvered plant of *Lupinus arboreus* (attacked by *Stereum purpureum*) gave rise only to normal seedlings.

XI. "TRUE" AND "FALSE" SILVER-LEAF.

Bintner (1) has attempted to distinguish between silver-leaf caused by *Stereum purpureum* and the silvery symptoms which are sometimes found in herbaceous plants and which are unassociated with this fungus. The former he denotes as "true" and the latter as "false" silver-leaf disease. In our experience silvery symptoms in leaves represent a whole complex of phenomena which cannot be classified in this simple manner. In an earlier paper of this series (3) curious examples* of silvered foliage were described, due respectively to insect attack and to excessive water-loss, as well as examples which histologically as well as superficially showed all the symptoms of silver-leaf disease caused by *Stereum purpureum*. In silvered plum seedlings and in silvered herbaceous plants, e.g., *Paeonia officinalis, Urtica dioica, Lamium album*, etc., the affected leaves show not only the partial separation of the epidermis from the mesophyll, but the same tendency for the mesophyll cells to separate one from the other as in silvered plum foliage caused by *Stereum purpureum*. With such characters in common it is impossible to speak of "true" and "false" silver-leaf. In this connection it is well to reiterate that in silver-leaf caused by *Stereum purpureum* the influence of the fungus in causing the peculiar histological symptoms is entirely indirect. Our point of view is that although the direct cause (at present unknown) of the histological disturbance ordinarily associated with silver-leaf disease is probably the same throughout, the indirect causes (e.g., *Stereum purpureum*) are very diverse. The really serious effect of silver-leaf disease caused in fruit trees by *Stereum purpureum* is not the silvering of the foliage, which is only an accessory symptom, but the dying back of the trees due to permeation of the wood by the mycelium. From the fruit-growers' standpoint silver-leaf disease is due to *Stereum purpureum* and that is the enemy to be combated.

* Similar silvering effects have recently been seen in poplar leaves affected by *Taphrina aurea* where the upper surface was distinctly silvery owing to optical disturbance although there was no internal separation of the mesophyll cells. Likewise certain varieties of apples showed a peculiar silvery sheen of the foliage after the long drought of 1921 although there was no internal disturbance. In these apples the epidermal cells appeared to have lost their turgidity.

XII. TREATMENT.

It is sometimes claimed that a cure has been discovered for silver-leaf disease, but at present we know of no cure for this disease which can be recommended without grave risk of failure. Some of these claims are based upon the behaviour of a few trees in which the forces of natural recovery have prevailed and not the treatment.

With the recognition of the factor of natural recovery it is clear that anything which can be done to aid it, will be of assistance in the struggle against silver-leaf disease. Good drainage, good cultivation and the facilitation of active growth by any means whatsoever, all favour the forces of natural recovery against this disease. Vigorous growth is often promoted by the addition of manures, either farmyard or artificial. Certain preliminary trials with artificial manures have given hopeful results as regards leading to recovery of silvered trees, but trials on a larger scale will have to be carried out before confident advice can be given. In these preliminary tests applications of kainit and basic slag to silvered plum trees in December and February had beneficial results.

Ring-barking of silvered branches is sometimes stated to be a cure for the disease. In this operation a ring of bark a quarter of an inch in diameter and about three-quarters of the circumference is cut away in the spring some distance below the lower extension of silvered foliage. In some trees which we have seen, this operation has been followed by recovery,* but the number of trees as yet treated in this way are too small to base final conclusions upon. We have ourselves experimented with this method on a considerable scale, but with little success so far.

In the previous paper of this series on silver-leaf disease (3) preliminary work on attempts at curative treatment of silver-leaf disease by injection was described. This has been continued, but without success, and at present there seems to be little hope of discovering a substance which can be easily injected into a silvered fruit tree, which is readily diffusible, and which while harmless to the host is toxic to *Stereum purpureum*. It is not worth while to describe these injection experiments in detail. Suffice it to say that dyes such as eosin, gentian violet and other substances such as sodium arsenate, were placed in solid form in a series of holes spirally arranged around the basal part of the trunks of affected trees in the hope that they would readily diffuse into the tissues permeated by the fungus when the transpiration current became active.

* Mr. E. Neal, gardener to Mr. E. Nix, of Tilgate, Sussex, is believed to be the first person to have employed this method, and we are much indebted to him for opportunities to examine the trees he treated in this way.

Where injection took place into wood killed by the action of *Stereum purpureum*, and which probably was no longer functional in carrying the sap stream, great differences in diffusibility were shown by these substances : e.g., gentian violet was far less diffusible than eosin.

Treatment by plant sanitation.

If silver-leaf disease cannot be cured in the medical sense, it can be prevented in great measure by following the methods of plant sanitation (5). Preventive measures fall under three heads :

(1) Prevention of the fungus, *Stereum purpureum*, from fructifying within and on the confines of fruit plantations, i.e., the abolition of the source of infection as far as this is practically possible.

(2) Avoidance of giving opportunity to *Stereum purpureum* to invade fruit trees through wounds. In the past there has been far too much cutting out of branches of mature trees. Fruit trees should be shaped properly when young, after which they should be left alone, apart from any necessary pruning of young shoots.

(3) If wounds must be made in fruit trees as in certain nursery operations and in cutting away branches broken by excessive weight of fruit, the exposures should be covered *immediately* by an antiseptic, such as gas tar. A second application of the antiseptic should be given within three months. If continuous protection could be afforded to these wounds, the fungus could not enter ; the present state of our knowledge indicates that the most critical time for invasion by *Stereum purpureum* is immediately after exposure, so that this should be avoided at all costs.

In recent years the Ministry of Agriculture and Fisheries have insisted, by administrative order, upon the eradication of all dead wood likely to harbour *Stereum purpureum* in fruit plantations. One result of this Order has been the removal of thousands of plum and apple trees killed through silver-leaf disease, which were a prolific source of infection. A change has recently been made in the date by which cutting out of dead wood in fruit plantations must be made (Silver-leaf Order of 1923). The present date is July 15th, which will lead to the removal of dead wood when there is a clear differentiation from healthy trees and which coincides with the period when spore production by *Stereum purpureum* is usually at a minimum. Tree stumps such a poplars on the borders of fruit gardens should be eradicated, as they are a common source of *Stereum purpureum*, and where the fungus fructifies abundantly on stumps of trees just outside fruit

plantations, an arrangement should be made, if possible, to remove them. The prevention of the formation of fresh crops of spores by the destruction of dead wood in fruit plantations is already having an effect in reducing the incidence of silver-leaf disease. In destroying fruit trees which have died from this disease, care should be taken to remove the main roots in case these become exposed and give rise to fruit-bodies of the fungus. There is no reason why new trees should not be planted where old ones have been removed, as the danger of root infection is negligible. No attempt should be made to keep grubbed trees piled on the premises, otherwise fructifications will arise on them. In Kent it has been found that dead plum trees can be used for making charcoal.

It is less easy to give explicit advice upon the desirability of cutting out silvered branches of fruit trees. With apples, in which the rate of natural recovery is high, it is generally inadvisable to removed silvered branches unless these are actually beginning to die back. With plums the advisability of cutting silvered branches away depends entirely upon circumstances. If certain branches have just begun to be effected, these can often be removed with advantage to the rest of the tree, provided that the wood actually infected is cut away. If, however, the tree is generally silvered, the fungus probably exists in the trunk where it cannot be excised, and the only sound policy is to wait until the tree begins to die back or alternatively to recover. Silvered branches often bear much fruit and there is no danger of infection from them until they die back.

In regrafting apple trees there is grave risk of infection by *Stereum purpureum*, and with such a variety as Newton Wonder the chances of attack are so great that in general it seems inadvisable to regraft this variety. Where apples are regrafted, it is usual to head them back some months before the grafts are inserted. In such cases the exposed surfaces should be covered with a protective substance, such as gas tar, and immediately before the insertion of the grafts the stems should again be cut back, so as to eliminate all discoloured tissues. The exposures should then be covered with clay, " pug " or grafting wax.

In nursery work, attention has already been called to the chief opportunities for infection by *Stereum purpureum*. If silver-leaf disease appears in a nursery the only safe rule is to destroy forthwith the affected trees. Reputable firms will not countenance the presence of silvered stocks or worked trees upon their premises. Unfortunately, fruit trees are sometimes propagated casually from silvered suckers by persons with no reputation to lose. If these suckers actually contain *Stereum purpureum*, the fungus will probably spread into and kill the young trees after a season or two. Examples of this kind have actually been seen. The remedy for this would appear to be in the public limiting their purchases to reputable firms who would not countenance such a practice.

XIII. SUMMARY.

(1) Some additional hosts for silver-leaf disease caused by *Stereum purpureum* are mentioned, including certain kinds of roses and pears.

(2) Attention is called to the damage recently inflicted by the disease upon peaches (under glass), Morello cherries, and certain varieties of apple, e.g., Newton Wonder and Early Victoria.

(3) The incidence of certain, almost epidemic, outbreaks of silver-leaf disease in apples and plums, is related to previous careless treatment of the trees, especially the provision of facilities for infection through cutting out large numbers of branches.

(4) The occurrence of silver-leaf disease in nurseries is discussed, and the critical times for infection of nursery stock are pointed out.

(5) The influence of the type of stock on the susceptibility of Victoria plums is considered. All plum stocks so far tested have proved susceptible to artificial infection by *Stereum purpureum*, but some are more resistant than others.

(6) Arguments, partly based upon pathogenicity, are advanced against the separation of *Stereum rugosiusculum* from *Stereum purpureum*.

(7) The preference of *Stereum purpureum* for woody tissues uninvaded by other micro-organisms is pointed out.

(8) The effect of the fungus upon invaded plum wood, including the process of gum formation, is described.

(9) The causes of natural recovery of silvered fruit trees are considered; it has been found that one of the chief factors is the formation of a peculiar zone of dark gummy substances in the periphery of the diseased wood, which cannot be permeated by the fungus.

(10) Further information is given as to the exact means by which *Stereum purpureum* infects fruit trees. It can readily infect newly-exposed woody tissues from one year old upwards, and there is evidence that such tissues are more readily infected by spores than tissues which have been long exposed. Snags and broken branches are particularly liable to infection by *Stereum purpureum*.

(11) A preliminary investigation has been made upon the nature of the micro-organisms which invade pruning wounds of plum trees. These organisms are chiefly fungi of different kinds.

(12) Various protective substances for dressing wounds in fruit trees have been tested. Gas tar has generally given the best results so far, and there is no danger of this substance damaging the bark if carefully applied. The use of Stockholm tar for this purpose cannot be recommended.

(13) Information is given as to the longevity of the spores of *Stereum purpureum* under different conditions, and as to the toxicity of various substances to the fungus in culture.

(14) Silvered plum leaves photosynthesise, but less actively than healthy leaves. Translocation of carbohydrates from silvered leaves proceeds more slowly than from healthy leaves. Silvered leaves wilt more readily than healthy ones.

(15) The attempt to differentiate "true" from "false" silver-leaf is considered to be invalid.

(16) Treatment :

(*a*) There is no known *cure* for silver-leaf disease, but every effort should be made to facilitate natural recovery of silvered trees by good cultivation and manuring.

(*b*) The disease can be *prevented* in great measure by the destruction of dead wood within and on the confines of fruit plantations on which *Stereum purpureum* might develop, by thinning and pruning fruit trees no more than is absolutely necessary, and by covering exposed tissues immediately with an antiseptic such as gas tar.

XIV. REFERENCES.

1. *Bintner, J.* Silver-leaf Disease, Kew Bulletin, 1919, p. 241.
2. *Brooks, F. T.* Silver-leaf Disease, I. and II., Journ. Agric. Science, 1911 and 1913.
3. *Brooks, F. T., and Bailey, M. A.* Silver-leaf Disease, III., Journ. Agric. Science, 1919.
4. *Brooks, F. T., and Bartlett, A. W.* Two Diseases of Gooseberry Bushes, Ann. Myc., 1910.
5. *Brooks, F. T.* Plant Sanitation in Fruit Plantations, Trans. Brit. Myc. Soc., 1920, p. 253.
6. *Brooks, F. T.* Some Present-day Aspects of Mycology, Trans. Brit. Myc. Soc., 1923.
7. *Burt, C.* Monograph of the North American Thelephoraceæ. Annals Missouri Bot. Garden, 1921.

8. *Butler, C.* A Study on Gummosis of Prunus and Citrus, etc., Ann. Bot., 1911, p. 107.

9. *Cunningham, G. W.* Silver Blight, *Stereum purpureum*, its appearance, cause and preventive treatment, N. Zealand Journ. of Agric., XXIV., 1922, p. 276.

10. *Dixon, H. N.* Transport of Organic Substances in Plants, Brit. Association Report (Hull), 1922.

11. *Güssow, H. T.* Der Milchglanz der Obstbäume, Zeitschrift für Pflanzenkrankheiten, XXII., p. 385.

12. *Humphrey, C. J., and Flemming, Ruth M.* The Toxicity to Fungi of Various Oils and Salts, U.S. Dept. of Agric., Bull. No. 227.

13. *Prillieux, Ed.* Etude sur la formation de la gomme dans les arbres fruitiers. Ann. des Sci. Nat. (Botanique), sér. 6, 1875, p. 176.

14. *Rumbold, C.* The Injection of Chemicals into Chestnut Trees, Amer. Journ. of Botany, 1920, p. 1.

RED PLANT IN STRAWBERRIES AND ITS CORRELATION WITH "CAULIFLOWER DISEASE."

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INTRODUCTION.

The disease in the Strawberry plant known by the various names of "Red Plant," "Red Leg," "Red Leaf," and "Small Leaf" has been recognised by some growers for a number of years. It is only recently and more especially in 1922 and the present year that the symptoms of the disease have become increasingly familiar, and the extent of its distribution recognised. To such a degree is this the case that in certain districts the Strawberry growing industry is seriously threatened. Definite evidence of its existence is forthcoming from Cornwall, Devon, Somerset, Hampshire, Herefordshire, Gloucestershire, Kent, Wisbech and the Valley of the Clyde. The disease has not been reported from Herefordshire but the symptoms have been identified in that county by one of us.

Cauliflower disease of Strawberries has been known for some thirty years and was first discovered by Mrs. Ormerod. Our observations lead us to the conclusion that Red Plant is only a type of this disease and the evidence for this statement is given below.

Diagnostic Characters of "Red Plant."

The typical "Red Plant" as seen in early Spring may be briefly described as follows—(this description refers to symptoms shown by the variety Royal Sovereign).

General Appearance.—The more prominent symptoms are most easily recognised when growth begins in the Spring. The chief feature of afflicted plants is the deep blood red colouration of the young petioles and the under sides of the unfolding leaflets. In the case of the latter the colouration may be more accurately described as "plum."

In comparison with normal plants, "Red Plants" tend to be undersized, this being most marked in the case of long-standing infections. In addition, blindness or partial blindness is usually present.

Fig. 36.

A Typical "Red Plant."

Photo by A. D. Turner.

Detailed examination reveals the following :—

Leaves and Leaf Stalks.

(*a*) *The Petiole.*—Two main types are shown.

(1) That which tends to be swollen at the base and tapering at the apex. This petiole is, generally, of a deep red colour and, invariably, long in proportion to the size of the leaflets which it carries.

(2) That which may best be described as a petiole and leaf in miniature (in extreme cases most minute) usually heavily suffused with red.

A diagnostic character of both these types is the marked reduction in hispidity amounting frequently to a sparse pubescence.

(*b*) *The Leaflets* which are borne on petioles described under (*a*) show considerable variation. In advanced cases of infection they may be represented by mere remnants of only one or two of the midribs, and from this show all grades up to small but perfectly formed reddened leaflets. A frequent symptom is the reduction in size of one leaflet or its complete absence accompanied by deformities in the two surviving leaflets. Before complete expansion these leaves may be compared in appearance with the developing fronds of bracken when but a few inches high. (We feel this simile to be so apt that we have adopted the term "frond" to describe this condition of growth and propose to use it for such in this and subsequent papers on this subject.) Working further up the scale towards normality leaflets are found in which the stunting effect is far less marked, and the deformities are reduced to curled and cup-shaped leaves, the latter being apparently due to some inhibition of marginal growth.

(*c*) *The Stipules.* These are frequently large in proportion to the length of the petiole and of a very deep red colour, but it must not be taken that this character is constant.

The Crown.—The crown is usually attenuated, more especially in the case of blind or partially blind plants. In cases where the plant has apparently contracted the disease at a very early age the formation of lateral crowns may be entirely inhibited, although such severe examples are rarely found. In other cases lateral crowns are produced but are extremely small and thin and give rise to the miniature leaves referred to above under (*b*). Where the infection is slight the size of the lateral crowns may be normal in comparison with the original crown but all are undersized and attenuated.

Diagnostic Characters of Cauliflower Disease.

True "Cauliflower Disease" is a condition caused by *Aphelenchus fragariae*. Ritz. Bos. The lateral crown becomes much swollen and the flowers stunted

and distorted into a cauliflower-like bunch from which the disease derives its name. The blossoms, when they appear, show a variety of deformity. The calyx may be enormously developed and the receptacle undersized and irregularly formed. In cases of medium infection the inflorescence, instead of remaining bunched as in the true cauliflower condition, is able partially to develop, but the scape and the pedicels are much thickened and stunted and the flowers of the cyme show considerable malformation. Frequently the scape is much fasciated.

To go into the details of foliar malformation—extreme cases are those in which the petiole is represented by nothing more than a short swollen protuberance sharply tapering to a fine point which is frequently dead. Working upwards from this as the lowest expression we pass, by way of the typical "fronds," through the leaf with the swollen petiole and either two leaflets and a rudiment, or two leaflets and the third deformed and twisted in various ways, to the next stage, a leaf consisting of three leaflets which exhibit a very characteristic crumpling or curling. In all case where leaflets of the above types are produced they are characterised by a tough leathery texture. In this disease, as normally recognised, there is no marked redness, the typical colouration being a blue-green tint about the leaves.

The miniature leaves of "Red Plant" are also often produced. These have been already described above.

Correlation of the Two Diseases.

We have had the opportunity of examining a very large amount of material and we found a constant overlapping of symptoms of "Red Plant" and "Cauliflower" disease.

To begin with, the typical colouration which gives the "Red Plant" its name, may greatly diminish after a few weeks. Stripped of this character the plants may present an appearance identical with mild cases of Cauliflower disease with the flower trusses removed, the bases of their petioles more particularly assuming the watery green colour typical of the thickened parts of cauliflower plants. This loss of colour we have carefully followed in marked plants in the observation plot at this Station. This plot consists of 5,000 plants, a very high proportion of which are "red."

Having fully acquainted ourselves with the characters of bad cases of Cauliflower disease we proceeded to work down the scale of degrees of infection noting the slightly changing symptoms. As we established the latter we found ourselves, towards the end of the scale, examining plants which normally we should have put down as "Red Plants," the cauliflower symptoms merging

Fig. 37.

Foliage from "Red Plant," showing Largest and Smallest Leaves.

Photo by W. Camps.

Fig. 38.

Foliage from a Normal Plant, showing Largest and Smallest Leaves.

Photo by W. Camps.

Fig. 39.
A Typical "Cauliflower" Plant.
Photo by W. Camps.

Fig. 40.
Advanced Stages of "Cauliflower" Disease.
Photo by W. Camps.

with the finest gradation into those of the latter disease. In some cases we have found blossom trusses on red coloured " Red Plants " which, we were able without hesitation to say, were typical of " Cauliflower " disease.

The connecting characters are as follows :—

(1) The production of the " fronds " described above in their various stages of development.

(2) Reduction in the number of leaflets.

(3) Deformity of surviving leaflets, one type of which is that of a leaflet very greatly reduced in size, having the marginal growth inhibited, and a resultant appearance of suffering from caterpillar attack, as though large " bays " had been eaten out of the margin. These leaves show an inhibition so general that very little central growth takes place, while in larger stronger leaves, although the marginal growth is checked, the central growth proceeds more or less normally with the result that a bellying of the leaf takes place.

(4) Deformation of the leaf margin including an " oak-leaf " type.

(5) Coarsening and thickening of the leaflet, such leaflets having a dark green colouration.

(6) Crumpling of the leaflets and the cup-shaped formation described above.

" Small Leaf."

There is yet another trouble of strawberry plants which some growers recognise as " Small Leaf."

This condition may be described as follows :—

The early stage is characterised by fine undersized growth accompanied by a certain amount of reddening, which later diminishes. Soon, excessive crown formation begins and is continued until a dense mass of leafage is produced. The petioles, leaflets and crowns are perfect in form but undersized, the majority of the latter being blind. The whole plant in fact appears a dense mass of undersized and attenuated growth, accompanied by partial or complete blindness.

At the bases of the crowns are found, as the result of careful examinations, numerous fronds and small deformed leaves comparable with those found in " Red Plant " or " Cauliflower " disease, and from this fact and the finding of *A. fragariae*, we are led to conclude that *A. fragariae* is in this case also the pathogenic organism.

Conclusions.

A consideration of all the above factors leads one to conclude that " Red Plant " and " Cauliflower " are one and the same disease and that the differences are, either different types of reaction on the part of the plant to the same noxious stimulus, or different degrees of infection, or again the result of infection contracted at different stages of growth. An examination of the large quantity of material which we have had at our disposal from several different districts would by itself almost suffice to convince one that the two diseases were the same, but still further and more convincing evidence is provided by the fact that *Aphelenchus fragariae,* Ritz. Bos. has been found and can always be found (although at times in small numbers) in the growing points of " Red Plants." Their position and method of feeding are identical with those in undoubted " Cauliflower " diseased plants, that is, they are to be found between the developing leaf rudiments on each side of the growing point.

The question of immunity of certain varieties will naturally arise. All that can be said at present is that none of the fifty varieties examined up to date have shown any immunity.

With regard to propagation—we are led to conclude that the stolon, and hence the young plant produced upon it, can be infected from the parent plant. At the same time it is not improbable that infection can take place through soil being carried about by boots, horses and implements, yet up to date many such young plants have been found to be infected ; careful roguing and burning of infected parent plants cannot fail to assure a considerable reduction.

These investigations so far have simply elucidated the cause of the diseases described above, and we have been led to publication at this stage in view of the large number of enquiries received from growers as to the cause of " Red Plant."

The life history of the eelworms, the methods of infection and possibilities of contact all remain to be studied.

We feel that the term " Red Plant," " Red Leaf," or " Red Leg " is an unfortunate one as, firstly, redness does not persist even in Royal Sovereigns and, secondly, although other varieties get the disease they do not go " red."

We wish to extend our thanks to Dr. T. Goodey of the London School of Tropical Medicine for identifying eelworm material sent to him.

SUMMARY.

(1) " Red Plant " and " Cauliflower " disease of the strawberry are due to *Aphelenchus fragariae.* Ritz. Bos., and are simply different responses to attacks of the same pathogenic organism.

Fig. 41.

Types of Foliage found on both "Red Plants" and "Cauliflower" Plants.

Photo by W. Camps.

1—Normal Truss. 2,'5—No Stamens, Abortive Flowers. 3—No Styles. 4—Truss from "Red Plant."

FIG. 42.

FLOWER TRUSSES FROM "RED PLANTS" SHOWING NORMAL AND TYPICAL CAULIFLOWER SYMPTOMS.

Photo by A. D. Turner.

(2) The factors governing the production of " Red Plant " as opposed to " Cauliflower " remain to be studied.

References.

Theobald. " Insect and other allied Pests of Orchard, Bush and Hothouse Fruits."

Ritzema Bos. " Zeit fur Pflanz. Krank." 1891.

Stewart. *Parasitology*, Vol. XIII., No. 2.

Schwartz. Arbeit. aus der K. Biolog. Aust für land-und ferst wistschaft. Vol. VIII. 1910-13.

Wellington. G. C. May 29th, 1920.

NOTES ON A TRIAL OF GOOSEBERRIES.

By EDWARD A. BUNYARD.

The very large number of Gooseberries which have been named and introduced in England mostly date from the first half of the nineteenth century. How many varieties now exist it is of course impossible to say, but there are probably five hundred or even more still grown in nurseries and gardens. From these have been selected certain varieties with the qualities which make them desirable for market culture, but as they do not number more than two or three dozen it seemed likely that an investigation of the lesser-known varieties might reveal some neglected fruits of promise for market culture. For this purpose the writer has collected some two hundred and fifty varieties of Gooseberries, and these have been studied during the past seven years. For considerations of space the main collection has been grown in cordon form, but most of the varieties have been propagated, thus allowing their habit of growth and facility for rooting to be noted. With but few exceptions it may be said at once that the gooseberries grown for market to-day represent a very good selection, so far as the varieties in this trial show, and in many respects could not be improved. This will be better brought out in the following consideration of the various colour groups and it will be seen that in nearly all cases the largest, most productive and vigorous variety from the group has already established itself as a market variety.

Classification by Colour.

Gooseberries are easily grouped into distinct colour classes and all previous writers on this fruit have followed this obvious division.

As with most things in nature, however, such classification has its limits and however useful and easy on paper it is apt to break down when the actual fruits are so placed. In the green varieties for instance, the dark sea green of Ocean is at one end of the scale which passes almost into the whites in such varieties as Alma and Postman.

These faint colour differences so difficult to describe and yet so patent to the eye are not merely the refinements of the systematic observer, they have a very practical value when Gooseberries are seen in bulk and add or detract greatly from the selling value of the sample. The clear bright yellow of Sandwich Yellow compared with the duller and greener colour of Golden Gem is a good illustration of this point.

It it, however, possible to sub-divide the four main colour divisions into groups which to a certain extent enables one to group together these shades of

colour, although closely followed this would in a few cases lead to a class of one variety only.

Such a grouping has a value as a classification, but as a key it reaches its limitations very soon as there are so many fruits which are not so distinguishable when gathered, but are obviously different in tree characters. An example may be found in the two well-known market fruits, Lancashire Lad and Whinham's Industry, which are hardly to be separated if mixed in a basket. The trees would, however, not be confused by any practical grower and even the leaves alone are easily distinguished by the downy upper surface of Lancashire Lad, while Whinham's is smooth.

It is not intended here to attempt such a classification, but to give briefly the outstanding results of this trial, from the market standpoint, and for this purpose the groups will be made around some well known variety as a type.

GREEN VARIETIES.

By far the largest number of varieties fall under this group, and it may be divided into the following groups.

Ocean—The darkest sea green.

Matchless—Medium Green.

Surprise—Yellow Green.

Alma—Milky green of cloudy appearance.

Whitesmith—Pale Green with yellowish tinge, transparent.

THE OCEAN GROUP. Deep Sea Green.

This group includes the darkest of the greens and are very easily distinguished. The colour is of a deep sea green without any tinge of yellow. The largest in this group are Telegraph, a smooth oblong variety ; Greenock, a roundish oval, slightly hairy ; Overall, a round downy fruit ; and Ocean, nearly round and smooth. None of these are particularly vigorous in growth and probably Ocean is the most likely sort for market growth.

MATCHLESS GROUP. Green with cloudy white.

The outstanding fruits in this group are Thumper, Galopin and Union Green and the type. These are all very similar in appearance and habit, but being all rather of weak straggling growth, are not promising from the market point of view. These all ripen about the same time.

ALMA GROUP. Greenish white.

These are quite distinct in colour from the Matchless Group, being decidedly more white. The main varieties are Alma, Plunder, Postman and White Swan.

All are oblong-oval in shape, and all rather late, except White Swan, which is one of the best early varieties, coming in shortly after Yellow Rough. This variety makes a small bush only, but for its earliness deserves the attention of the market grower.

Surprise Group. Pale yellow green, slightly transparent.

The colour of this group is distinct, and though close to the Whitesmith group has distinctly a more yellowish green. All are of oblong or square-oval shape and slightly downy. The fruits are practically identical, but considerable variation in growth is present, from the upright habit of Philip, I, to the drooping growth of Surprise. The principal varieties this group are Philip I, Random Green, Shiner, Surprise, Bang Europe, and British Queen.

The Whitesmith Group. Pale green with marked down, giving an effect of bloom.

The type of this group is so well-known as to need no description. The following resemble it very closely in fruits: Chatauqua (I think identical), Wellington Glory, White Lion, Fearless, Jolly Angler, Smith's Nonpariel, Fairy and Progress. The last-named is distinctly later, but the others are all of similar season of ripening.

Lancer must fall in the group, as though much larger than any of the other, it is exactly the same colour. Here I think Whitesmith stands out for vigour and crop and Lancer for the same qualities, and thus the best of this class are already selected as market varieties.

White Varieties.

The Careless Group. White.

This group contains the whitest fruits, of which Careless is perhaps the best known. For an early fruit Mitre has claims to attention; it is of excellent flavour and the tree characters fairly good. Postman is also a good late variety, making a moderate spreading bush. Others of this section are White Eagle, Tally Ho (late), Sir George Brown. Transparent also belongs here, but is rather more green and forms a link between the greenish whites of the Alma group and that under consideration.

Yellow Varieties.

The Catharina Group. Golden Yellow.

Though yellow Gooseberries seem sufficiently distinct from all others to make a class by themselves, we find on examination that they fall really into

three sub-classes, viz., Early Sulphur is a class by itself—I have not so far found any similar colour. Catherina is of a pale colour, and around this variety would fall such varieties as Cousen's Seedling, Mount Pleasant, Golden Lion and Peru. Golden Gem almost deserves another class by itself there being nothing so far as I know of this remarkable golden yellow. This variety is comparatively new (introduced in 1897) and has probably not been tried to any extent for market use yet. It is a fair cropper and of moderate spreading growth.

Several other so-called yellows belong more properly to that curious olive yellow class of which Gunner is a representative.

THE LEVELLER GROUP. Yellowish Green.

This group and the following Leader group might perhaps be placed together. There is, however, a very distinct olive green about the Leader family, which the Leveller group does not show. The Gunner group are also very closely allied, but they lack the green shade and are really a dull yellow with a rather transparent skin. Leveller is now so well known that it hardly needs description, and the remainder of this group are very similar indeed in colour. High Sheriff, Railway (late), Trumpeter, Mount Pleasant (exactly like Leveller in fruit, but differing in tree habit), Pretty Boy and Lady Popham are good representatives. The last is very late, ripening with Cousen's Seedling.

THE LEADER GROUP. Dull Olive Yellow.

The curious lurid colour of these is well shown in the typical variety from which the group is named. They can hardly be said to be attractive, having rather the appearance of unripe Levellers. The outstanding varieties for size are Coiner, Ringer, Lord Scarborough, Lord Rancliffe, Drill, Independent, and of a darker olive still, Thatcher.

THE GUNNER GROUP. Dull Dark Yellow.

Of this group Gunner is the only large fruited representative I have found. Small varieties which come in this class are Rambullion, Huntingdon Lass, and Yellow Ball. Gunner is already known as a market fruit and is obviously the only one for this purpose in my collection.

RED GROUPS.

In the red colours very little variation is found. Most of them turn a dark blackish red when fully ripe and must be marketed before fully ripe if an attractive colour is desired. The notable exceptions to this are Warrington, Keen's Seedling, Rose of Sharon, and to a less extent Lord Derby. It is more convenient therefore to divide the reds into three groups according to size.

Small Reds.

In this group come such varieties as Red Rough, Red Champagne, and Keen's Seedling, which are hardly of market interest.

Medium Reds. Whinham's Group.

This group will include such well-known varieties as Whinham's, Lancashire Lad, May Duke, and Rifleman. Others less known are Flixtonia, Collie's Lane, Prince Regent, Crown Prince, Lion's Provider.

It seems hardly necessary to search for others in this class, as those first named above are in so many respects ideal market varieties. There may, however, be certain points, such as resistance to disease, which a further trial will reveal.

Large Reds. London Group.

These are mostly prize berries and have won their renown on the show table rather than on the market. A few are already known as market fruits, such as Napoleon le Grand and Bobby. The last seems likely to resist American Gooseberry Mildew to some extent. Others which fall in this class are Foreman, Eskender Bey, Dean Swift, Red Robin, Duke of Sutherland, Speedwell, Falstaff, Beauty (very late), Lord Audeley, Slaughterman, Highlander and Sportsman.

It must again be emphasised that there are a large number of Gooseberries which were not included in this trial, and therefore those above indicated as good or worthy of further attention are not necessarily the best.

One point emerges very clearly from the study of these Gooseberries, and that is that it is impossible to name fruits accurately without including the tree characters. The numerous members of the Whitesmith family are in many cases identical as to fruit, but very distinct when growing the tree is seen. Fuller descriptions of the varieties named above will appear in my forthcoming volume on Bush Fruits.

THE PEARS OF NEW YORK.

By U. P. HEDRICK, assisted by G. M. HOWE, O. M. TAYLOR, E. H. FRANCIS, H. B. TUKEY.

Dept. Agr. State of New York. Albany. 1921. 636 *pp.* 80 *plates.*

The now well-known volumes which Dr. Hedrick is producing follow each other with inevitability and majesty hardly to be matched outside the Wagnerian cycle and the effect on the would-be critic is much the same in both cases. How petty seems the usual small beer of criticism ; the misprints, the omissions, in the face of the weight and splendour of these magnificent works. But the analogy soon reaches its limit. None could dispute Wagner's discords did he maintain their intention, but with a work which is a mountain of small facts it is possible for the smallest mouse to raise a critical squeak upon the discovery of a debatable point.

When one considers the thousands of observations which go to make such a book as this, observations in many cases of varying characters as to which the author must at some time take his courage in his hands and decide where the average line is to be drawn ; the thousands of references to literature, not all in one language, and of which each writer's idiosyncracy requires weighing, it is to be expected that some few errors will have crept in and some decisions taken which are disputable.

In the case of the " Pears of New York " such occasions for criticism are remarkably few.

In previous volumes the author has dealt at some length with the species from which our cultivated fruits may possibly have been derived. We turn, therefore, with some interest to this section in the present volume to see how the very tangled and speculative subject of the origin of the Pear has been treated. It is with some disappointment that we find the author has been extremely discreet, indeed his valour shows so much of its better part that he does not mention the speculations of Koch and Engler, and thinks with Decaisne that Pyrus communis has played an almost exclusive part in the parentage of the European pear. He admits the possibility of Pyrus nivalis as parent of the " Sage Leaved " Pears, mostly grown for Perry in Southern France, here following Decaisne.

It is, however, possible that this species has played a much larger part in the make up of our Western European Pears than Decaisne allowed, and that many are derived, in part at least, from it. The large flowers and densely woolly leaves of such Pears as Catillac and many other late stewing kinds, favour such a conclusion, and in our Early Chalk Pear little trace of Pyrus communis can

be found. The rather dwarf round headed trees made by these woolly leaved Pears strengthens the probability that they derive from Pyrus nivalis, which itself has this habit.

Dr. Hedrick also dismisses Pryus siniaca very briefly, but Koch thought this had played some considerable part in the history of our better flavoured Pears, and from its distribution in the cradle of Mediterranean civilisation this seems at least possible.

The descriptions follow the lines of previous volumes and the section describing the different characters of tree and fruit, and their systematic value is excellently done. The pose of the leaf, so striking a character in Pears, is discussed, but seldom used in the descriptions, leading one to think that they have been made from herbarium material rather than in the field.

This character of leaf pose is of great importance and is usually the first thing that strikes the eye, the closely folded leaves of Emile d'Heyst or Winter Nelis compared with the flat pose taken by those of Josephine de Malines, will illustrate this point. We note that " leaf fall " and autumn colour are mentioned as a useful character to include for diagnostic purposes, but are but seldom mentioned in the descriptions.

The authors have, as usual, been diligent in their search of literature and a large number of synonyms and references are given. We are, however, rather at a loss to know on what system they are recorded. In the preface we read that " The synonyms created by Pomologists whose works we have had, have been noted, but in no case are synonyms given only when quoted by pomologists from another writer." This rather cryptic sentence we have endeavoured to elucidate by a study of the methods of selecting synonyms, but without much success. We turn to Jargonelle and find Duhamel quoted as the first authority for the name Epargne, which is the original and correct name for our Jargonelle. On referring to the different Pear known from very old days in France as Jargonelle, and which the authors call " French Jargonelle," we find, again correctly, a reference to Duhamel's description of this. But as a synonym is given the name of Bellisime d'Ete, which Duhamel described as a distinct Pear, as also did Leroy in his " Dictionaire de Pomologie."

We also note in the abridged list of Pears, Beurre " Perran " described as a distinct variety, when in reality it is but Duchess de Bordeaux under a new name. To have done with our small beer of criticism we may suggest that Jargonelle is not used in France " to denote a group of Pears," but is applied to different varieties ; not quite the same thing. We suggest also to the authors that this name may probably have been derived from the Italian *Garcinole*, rather than from Jargon or Groecum. Merlet did not suggest this, as is stated on p. 177 ; he, discreet man, contented himself with describing his fruits and left to others the more dangerous task of ascribing origins.

On the same page it may be pointed out that Pliny's Numidianum and Groecum are two distinct varieties, as their geographical names would suggest, and not one.

British students will turn with great interest to the descriptions of the varieties which have been raised in America and we are glad to see that Keiffer and Le Comte are condemned in no unsparing way. The coarse, glassy flesh of these fruits and their relatives derived from the Chinese Sand Pears, lead us to express the fervent hope that no one will attempt to introduce these execrable fruits into general culture here and so bring disgrace upon the name of the delicious and melting Pear.

It is curious that many of our larger Pears hardly attain in America the size we associate with them here, Buerre Diel, Beurre Hardy and even the native Roosevelt are distinctly undersized compared with European samples, perhaps a question of rainfall.

Of the numerous illustrations it is pleasurable to be able to speak in the highest terms. The sober colours and matt surface of Pears renders them highly suitable for reproduction in colour and those concerned in the production of the plates deserve high praise.

Dr. Hedrick and his assistants have once more placed pomologists under a great debt to them for their fruitful efforts and the Englishman cannot but reflect that his country has not produced even one pomological treatise to compare with the detailed and sumptuous volumes which come from Geneva.

DATES AND DATE CULTIVATION OF THE 'IRAQ.

By V. H. W. DOWSON.

Published by W. Heffer & Sons, Ltd., Cambridge.

The literature of Date Growing is limited, and those who are interested in this subject will welcome the information gathered together by Mr. Dowson relating to Date cultivation in the 'Iraq. It may be thought the matter is of little value to readers of this paper, but there is much of interest to be found in these memoirs. As in all fruits of ancient history one is astonished to find the large number of varieties which are in existence. To the average Englishman there are probably only three or four varieties, but a further study reveals a very large number, even if we confine ourselves to Mesopotamia alone. A very interesting point brought out by the author is the remarkable facility which the Arab grower attains in recognising the different varieties. The writer of this review has endeavoured in Algeria to recognise differences in varieties which to the Arab are patent, but met with little success. The Mesopotamian Arab is able to pick out a large number of varieties by a glance at the tree alone, though if asked for the distinctions he is at a loss to supply them, but merely "feels" that it is the variety designated. The author brings out the great variation in yield and quality and that the selection of the better varieties should be carried still further.

The work is in three parts, Part I. dealing with the Cultivation of the Date Palm on the Shat Al' Arab, Part II. giving the Results of an Investigation into the Yield of Date Palms on the Shat Al' Arab, and Part III. deals with the descriptions of varieties. It is illustrated with many photographs and plans, showing the distribution of cultivation. Peculiarly interesting is the vocabulary of terms used by the native for the different parts of the tree.

Like other fruit plants Dates are not exempt from diseases, and striking pictures are shown of devastated orchards, showing there is yet much work to be done in this direction.

Mesopotamia has a rather unblessed signification in this country as a synonym for extravagance, but the price of these three paper covered volumes totalling some 200 pages, namely 25s., would lay the purchaser open to this reproach rather than the producers. It must be said that plans and charts are, as all authors know, an expensive luxury—and the author has been generous in this respect.

In his map of the distribution of the Date he includes Bordighera but omits Elche in Spain. As this town has a large commercial Date culture and is, we believe, the only place in Europe where dates are grown, this should be included in future editions.

TESTS OF FUNGICIDES ON APPLE TREES.—II.

AN ANALYTICAL STUDY OF THEIR EFFECTS ON THE TREES.

By N. H. GRUBB.

East Malling Research Station, East Malling, Kent.

Experiments on the use of fungicides on apple trees have been in progress at East Malling Research Station since 1919. A report on the first two years' work appeared in " The Journal of Pomology," Vol. II, No. 2 (February, 1921). After two years further work it was decided to discontinue the first series of these experiments, and to begin a new series on trees in other plantations, under somewhat different conditions. This report will therefore summarise the results obtained in the first series; the period covered extends from 1919 to 1922, and includes seasons with widely different weather conditions, and differences quite as wide in the prevalence of scab and other diseases.

In the first report it was attempted, so far as the writer knows, for the first time, to make a detailed analysis of the effects of fungicides on apple trees. Considerable attention was paid to their fungicidal effect in the season of application. But it was shown that they have other effects also. Some of these, such as the leaf fall and the russetting of the fruit caused by Bordeaux mixture, have been long known and widely studied, whilst others, such as their influence on general health and vigour, and their cumulative effect, have received less attention than their importance merits, and in some cases do not appear ever to have been previously observed. This second report adds to the data already published on these effects, and attempts to extend the study to several points not previously mentioned.

This analytical study has only been made possible by the keeping of individual tree records. The trees concerned are those employed in our study of the effects of various methods of pruning. From 1919 onwards an increasing number of records has been kept each year for every tree; these now include the number and weight of fruits matured (and of six varieties, the number and weight of scabbed fruits); the weight of prunings, and the number of new shoots cut in pruning from all pruned trees; the height and spread of the tree and the girth of its stem below the branches; the number of infections of apple canker and apple mildew (the latter recorded twice each year); and for a majority of the trees, the number of fruit buds.

Had these records been kept merely as averages from each group of trees, such an analysis as is here made would not have been possible. The length of time during which the spraying of a tree may modify its behaviour is here shown

to extend to several years; and since it has been thought desirable to vary the treatment of each individual tree from year to year, it is only by means of individual tree records that the effects of one year's treatment can be disentangled from those of other years.

It is arguable that still more detailed records might have revealed still other effects of the fungicide spraying. It was repeatedly observed this year (1923), for instance, that the scab on the leaves and fruit of both sprayed and unsprayed trees was closely confined to certain branches; even the unsprayed trees showed certain branches practically free from scab, whilst other branches were freely infected. It ought to be possible to discover a reason for this peculiarity; but nothing short of records for each branch separately would be likely to reveal it. Arrangements have been made to begin work on these lines.

The results obtained in 1921 and 1922 in the main confirm those described in the first report. An attempt to follow up the observations made in 1920 on the effect of fungicides in reducing the number of canker infections, however, has led to no result, owing to the scarcity of infections in 1921 and 1922. Further confirmation of some of the results was obtained in 1923 in the first of the new series of spraying trials; this new series is being carried on in collaboration with Mr. N. B. Bagenal, County Horticultural Adviser for Kent, to whose help in the work of spraying and recording I am very much indebted.

The methods adopted in these experiments have been more or less the same throughout the four years. None of the trees have been sprayed with fungicides before blossoming; in 1919, 1920 and 1921, trees of six varieties were sprayed immediately after the blossom fell, and again three or four weeks later. In 1921, trees of two additional varieties, and in 1922 trees of four varieties only, were sprayed once, immediately after blossoming; in these cases the injury caused by the first application was so severe that the second was abandoned.

The applications of fungicides have been made throughout as nearly comparable as possible. In 1919 and 1920 a small hand pump was used, and the pressure obtained, though not very high, was sufficient to give a fine misty spray. In 1921 and 1922 a petrol engine machine was used, and the pressure obtained was consequently much higher, and the spray finer and much larger in volume; but the application was carried out by the same persons, and was probably not appreciably heavier, though perhaps more thorough, than in the earlier years.

In 1922, a shower of rain followed the one application immediately, before the last sprayed trees had had time to dry. The trees from which most of the spray mixture was thus washed were carefully noted, and could if necessary be excluded in discussing the results. Since, however, the removal of the spray mixture by the rain would merely tend to reduce the average difference between

the sprayed and unsprayed trees, it does not seem necessary to omit them; a note to the effect that the differences should probably be greater than they appear will perhaps suffice.

Control of Scab or Black Spot (*Venturia inæqualis*).

In 1921 and 1922, of only one of the six varieties mentioned in the first report (Worcester Pearmain), were any trees left unsprayed. In addition, half the trees of Rival and of Lord Derby were sprayed once in 1921, the remainder being left unsprayed.

Both Worcester Pearmain (in 1921 and 1922) and Rival (in 1921) showed an appreciably higher proportion of scabbed fruit on the unsprayed trees; the greatest difference was shown by the untipped trees of Worcester Pearmain in 1921, the figures being 7.6 per cent. scabbed from the trees sprayed with lime sulphur, and 29.9 per cent. scabbed from the unsprayed trees. In general the results bear out those given in the earlier report, though scab cannot be said to have been prevalent in either 1921 or 1922.

Comparisons of various fungicides were continued in 1921. The rather dilute form of "excess lime" Bordeaux (6 lbs. copper sulphate, 20 lbs. lime, 100 gallons water—"6—20—100") used in that year gave a somewhat better control of scab (on Newton Wonder) than ammonium polysulphide with soap; the figures were 4.5 per cent. of scabbed fruit for the former, and 11.7 per cent scabbed for the latter. Bordeaux of the same formula gave a very slightly poorer control of scab (on James Grieve) than lime sulphur (1 to 59) with lead arsenate; here the figures were 11.8 per cent. and 11. 1 per cent. respectively.

Lime sulphur alone was tested in comparison with lime sulphur with lead arsenate on two varieties, Worcester Pearmain and Allington. Except on the unsprayed trees of Worcester, the scab attack was very slight, and any difference in control caused by the mixture with lead arsenate was negligible. Lime sulphur with lead arsenate was compared with ammonium polysulphide with soap on Bismarck and Cox's Orange; here again the scabbed fruits were very few, but there was a perceptibly better control in each case by the lime sulphur and lead arsenate.

In 1922 the use of "calcium caseinate" as a spreader for lime sulphur was tested on Allington and Beauty of Bath. The latter produced extremely few fruits, practically none of which were scabbed. The very few scabbed fruits of Allington did not show any reduction where the spreader was used, but rather the reverse; and this although the spreader gave an excellent mechanical result, the coating of lime sulphur on the leaves being far more uniform where it was used than where it was not.

The 1921 results show, I think, that the weak "excess lime" Bordeaux (6—20—200) is fungicidal, though probably slightly less so than lime sulphur

(1 to 59) with lead arsenate. The expected greater fungicidal value of lime sulphur with lead arsenate than of lime sulphur alone was not well shown, probably because of the scarcity of scabbed fruits. It was better shown in the the new tests started in 1923 ; but since in this case the methods adopted were somewhat different from those of the earlier series the results can hardly be compared.

Control of Apple Mildew (*Podosphaera leucotricha*).

It was shown in the earlier report that, while Bordeaux mixture has little if any fungicidal effect on apple mildew, this fungus can be at least partially controlled by lime sulphur or ammonium polysulphide. Further data on this point have been collected, and bear out the earlier conclusions ; as before, the observations have been confined to *wood* infections, which have been removed from the trees and counted twice in each year.

All the results confirm the conclusion just mentioned, that Bordeaux mixture is the least effective, of the fungicides tested, against apple mildew. There is still some reason to think that it has a slight effect ; as for instance on Lord Derby in 1921. Here sixteen trees sprayed with Bordeaux (6—20—100) showed, in the two following countings an average of about fifteen infections of mildew each ; whilst sixteen unsprayed trees showed on the average nearly seventeen infections. But wherever Bordeaux has been compared with other fungicides it has invariably been less effective in the control of mildew. Thus sixteen (untipped) trees of James Grieve sprayed with Bordeaux (6—20—100) in 1921 showed at the next two countings an average of nearly twenty infections of mildew ; whilst sixteen trees sprayed with lime sulphur (1 to 59) with lead arsenate showed an average of about 12.5 infections. Similarly with Newton Wonder, the figures were sixty-four and fifty for Bordeaux and ammonium polysulphide respectively.

In the earlier report it was shown that the brand of ammonium polysulphide used in 1919, with soap, was more effective against mildew than lime sulphur. A different brand, used in 1921, did not in this respect come up to expectations ; on both Cox's Orange and Bismarck lime sulphur with lead arsenate gave a slightly better control than ammonium polysulphide, the figures being, for Cox, seventeen and twenty-three, and for Bismarck 35.5 and 37.5 respectively.

The mixture of lime sulphur with lead arsenate, which seemed in 1920 to be considerably less effective against mildew than lime sulphur alone, proved in 1921, on Allington, to be distinctly more effective, the average number of infections being, at the next two counts, nineteen per tree for lime sulphur with lead arsenate, and twenty-seven for lime sulphur alone. The use of " calcium caseinate " with lime sulphur in 1922, on the other hand, did not increase its

control of mildew ; on Beauty of Bath it appeared actually to reduce it slightly, whilst on Allington the result was neutral.

After four years work one is not favourably impressed by any of the fungicides used for the control of apple mildew. Though in some of the tests mentioned in the earlier report the control was as high as 60 per cent., this would in few cases be enough to justify fungicide spraying specially for control of mildew. But where both mildew and scab are prevalent, there is the hope that a sulphur fungicide spray used for the control of scab will aid in the control of mildew.

Control of Apple Canker (*Nectria ditissima.*)

It has been stated above that the attempt to follow up the observations on apple canker described in the first report has led to no result, owing to the scarcity of canker infections in 1921 and 1922. But the first report appeared before the complete figures of canker infections in the winter of 1920-21 were available ; it will be worth while to give these here.

The final results with Worcester Pearmain were as follows :—Twenty-three (untipped) trees sprayed in 1920 were found in the following winter to have an average of 4.1 " old " infections and 11.6 " recent " infections ; whilst nine similar trees not sprayed had 7.3 " old " and 49.9 " recent." The result on the untipped trees of James Grieve was almost equally striking ; twenty-four sprayed trees had an average of 1.4 " old " infections and 9.1 " recent " ; whilst eight unsprayed trees had 2.1 " old " and 31.7 " recent." The " recent " infections were all bud infections obviously dating from after the leaf fall of 1920 ; the " old " infections could not be exactly dated, but certainly occured before the leaf fall. In spite of the very sporadic nature of the canker epidemic, it is clear that the fungicides did help to keep it in check.

It is unlikely that the different fungicides differed materially in their control of canker. Of Worcester Pearmain, the trees sprayed with lime sulphur with saponex had over 50 per cent. less infections than those sprayed with lime sulphur alone ; but this is probably accidental ; for on James Grieve the difference between trees sprayed with lime sulphur alone and Bordeaux (8—25—100) was negligible.

Spray Injury.

1. *Bordeaux Mixture.*

The comparison of " equal lime " Bordeaux with " excess lime " Bordeaux described in the first report has not been repeated. But since the latter had been found to cause a certain amount of " russetting " of the fruit, it was decided in 1921 to test a weaker form of the " excess lime " formula, namely 6 lbs. copper sulphate and 20 lbs. lime, to 100 gallons of water (" 6—20—100 "). This

was applied to three varieties, Newton Wonder, James Grieve and Lord Derby. The season of 1921 appeared to favour the development of fruit russetting by Bordeaux; James Grieve, sprayed twice after blossoming with Bordeaux (6—20—100) showed almost 20 per cent. of the fruit badly russetted, as compared with 1.5 per cent. from trees sprayed with lime sulphur; whilst Newton Wonder was still worse, the figures being 37 per cent. for Bordeaux and 0.3 per cent. for ammonium polysulphide. Lord Derby has long been known to be highly susceptible to Bordeaux injury (it was used for this reason); here one spraying with Bordeaux (6—20—100) immediately after blossoming resulted in about 70 per cent. of badly russetted fruits, as compared with just over 1 per cent. from the unsprayed trees. It is clear, then, that even this more dilute form of the "excess lime" Bordeaux may in certain seasons cause very considerable injury.

In respect of Bordeaux injury the season of 1923 appears to have been similar to that of 1921; for even Worcester Pearmain, which in our conditions is usually very resistant to Bordeaux injury, showed about 35 per cent. of the fruit russetted, by two applications of Bordeaux (8—8—100) after blossoming.

It is not intended to suggest, of course, that a certain amount of russetting will always reduce the value of apples of all varieties. Some growers even spray Cox's Orange with Bordeaux, and find that the russetting which results does not reduce the market value of the fruit; some say that they even get a higher price for russetted Cox's. But there can be no question that the russetting of our Lord Derby fruit in 1921 was a serious detriment; the sprayed fruit was hardly recognisable as Lord Derby, and could only have been sold under that name with considerable difficulty.

2. *Lime Sulphur.*

It was shown in the first report that lime sulphur applied as a spray to apples after blossoming is liable to reduce the crop; it appears to make the fruits drop when quite small, often to a very serious extent. The extent of this injury was further studied in 1921 and 1922, and the results were again checked in 1923, in the new series of tests.

In the first report the results presented showed only the number and weight of mature fruits per tree. This is not an entirely satisfactory measure of the fruit drop, since the trees vary greatly in the number of their blossom buds, and consequently in the maximum possible crop which they can bear. We now have records of the number of blossom buds borne by each tree, and can show the effect of lime sulphur on the proportion of the blossom which "sets." We also have two season's records of the number of small fruits which dropped in late June and July. Both these records give a better measure of the effect of lime sulphur than the crop of mature fruit.

Of the many records now available in which the blossom set of trees sprayed with lime sulphur, either alone, or in mixture with lead arsenate or a spreader, can be compared with that of unsprayed trees of the same variety, there is but one showing a higher percentage of blossom set on the sprayed trees. This one exception was a group of trees of Worcester Pearmain sprayed with lime sulphur and " Saponex " in 1920 ; attention was called in the first report to the heavier crop of the sprayed trees in this case. In one or two cases the percentage of blossom setting has been approximately equal on sprayed and unsprayed trees, but in nearly all there has been a marked difference in favour of the unsprayed.

The most remarkable example of this form of lime sulphur injury so far observed occurred in 1922. In that year, as in previous years, sixteen trees of Worcester Pearmain were left unsprayed ; the remainder were sprayed with lime sulphur at 1 to 49, with 5 lbs. of " calcium caseinate " as a spreader per 100 gallons of mixture. One application was given about a week after the last blossoms fell ; the intention was to give a second, but the fruit drop caused by the first was so heavy that the second was abandoned.

The proportion of the fruit which dropped was so much affected, as in previous years (as indicated in the first report), by the pruning which the trees had received, that the figures for " leader-tipped " and " untipped " trees must be given separately. These figures appear in Table I.

Table I.

Mature fruits as a per cent. of blossom trusses.
(Worcester Pearmain, 1922.)

Leader Tipped.			
Sprayed	24 trees	8.6%	(+2.6% small).
Not Sprayed	8 trees	38.6%	(+ 9.9% small).
Not Leader Tipped.			
Sprayed	24 trees	15.5%	(+28.7% small).
Not Sprayed	8 trees	28.1%	(+39.0% small).

It was not found practicable to count the number of actual blossoms on each tree ; the figures thus represent the relation between the number of mature fruits and the blossom *buds* or *trusses*. One might perhaps estimate that the blossom trusses of Worcester Pearmain would have, on the average, about six blossoms each ; if this were so, the figures would have to be divided by six to obtain the actual percentage of *blossom* set. The small undeveloped fruits so common on trees of Worcester Pearmain were recorded separately, and are given as separate percentages (in brackets) in the table.

It will be noticed that, if the small undeveloped fruits are disregarded, the blossom even of the untipped trees set nearly twice as well where they were not sprayed as where they were. On the tipped trees the difference was far greater, the percentage being about four-and-a-half times as high on the unsprayed trees as on the sprayed. This contrast between the two pruning groups is very striking. In the first report it was suggested that the cause might be found in the greater freedom of the leader tipped trees from scab; for if the scab thinned the fruit of the unsprayed untipped trees it might produce a contrast similar to the one we find here. But the fact that the blossom actually set better on the sprayed untipped trees than on the sprayed tipped trees makes this explanation unlikely; for most varieties, like the unsprayed Worcesters here, normally give a better set on the tipped trees.

The number of dropped fruits as a per cent. of the blossom trusses from these same trees of Worcester Pearmain is shown in Table II. The recording of the "drops" was continued until July 7th; at that time the "July drop" had practically ceased, and the dropping of properly set apples, which should have matured, had begun. The "drops" attacked by apple sawfly are excluded from these percentages, since there is no reason to suppose that their number was in any way affected by the spray.

TABLE II.

Number of dropped fruits (to July 7th) as a per cent. of blossom trusses. (Worcester Pearmain, 1922.)

	Sprayed.	*Not Sprayed.*
Leader tipped ..	67.4%	35.6%
Not leader tipped	35.3%	6.5%

It is somewhat difficult to account for the very much larger percentage of "drops" from the leader tipped trees than from the untipped trees, particularly where the trees were not sprayed. It will be noticed, however, that if the three percentages given in the two tables (mature fruits, small undeveloped fruits, and "drops") are added together the totals are not very far apart; they are nearer still if the "drops" attacked by apple sawfly are included. This seems to indicate that the figures are more or less reliable. The higher percentage of "drops" from the leader tipped trees corresponds with a higher percentage of small undeveloped fruits on the untipped trees, and suggests that many of the latter are early thrown off from the tipped trees, whether these are sprayed or not.

The fruit drop caused by lime sulphur was somewhat less in 1923 (two applications) than in 1922. The trees used in the new series of tests are bush trees of Worcester Pearmain, kindly loaned to us for the purpose by our

neighbour, Mr. Tolhurst. The pruning they have received has been somewhat less severe than that practised on our own leader tipped trees, but is otherwise similar. A comparison of ten unsprayed trees with ten trees sprayed twice after blossoming with lime sulphur at 1 to 29 gives the following percentages of blossom set (calculated as in Table I.), sprayed, 11.4%; unsprayed, 17%.

It was suggested in the earlier report that the fruit drop may possibly be reduced by the use of "spreaders" or lead arsenate in mixture with lime sulphur. Further investigation of this point has not led to any consistent result. As mentioned above, and in the first report, the use of "Saponex" with lime sulphur in 1920 gave at least an indication that the fruit drop might be reduced. This spreader has not been used again; but the "calcium caseinate" used as a spreader with lime sulphur in 1922 did not give an encouraging result, the "set" of blossom being if anything poorer where it was used than where it was not.

The mixture of lime sulphur with lead arsenate used in 1921 gave an uncertain and irregular result; some of the trees of Worcester Pearmain and Allington sprayed with the mixture gave a distinctly better "set" of blossom than those sprayed with lime sulphur alone, whilst others showed the opposite effect. This has been tested again in 1923, and has led to the deduction that where the trees sprayed with the mixture (lime sulphur with lead arsenate) give the better "set" of blossom, this is chiefly due to the control of insects by the arsenate.

It was shown in the first report that the brand of ammonium polysulphide used in 1919 appeared to have caused far less fruit drop than lime sulphur, either alone or with saponin. In 1921, another brand of ammonium polysulphide was used on Cox's Orange and Bismarck. The untipped trees of each variety showed a far higher percentage of blossom set where they were sprayed with ammonium polysulphide than where lime sulphur with lead arsenate was used; but the leader tipped trees did not show this difference, their percentage being approximately the same, whichever spray was used. In neither case was the number of trees (eight in each group) large enough to make the result trustworthy.

Since the fruit drop caused by lime sulphur spray has been observed for several years, in America as well as in England, it must now be taken as an established fact. It makes the use of lime sulphur as a summer spray for apples at best a risky proceeding. In certain seasons, when there is a heavy set of blossom and a tolerable certainty of a good crop, it may serve a useful purpose—not to mention its fungicidal value—by thinning the fruit. But in years of short crop the result may sometimes be as bad as that recorded here in 1922, when what would have been a moderate crop, judged by the unsprayed trees, was (at least in the case of the leader tipped trees,) almost wiped out by a single

spraying with lime sulphur (1 to 49) after blossoming. And this result is not confined to any one variety ; in our trials it has been definitely shown by the percentage of blossom set in Allington, Cox's Orange, Rival, Worcester Pearmain, and Newton Wonder ; and by crop figures in James Grieve and Bismarck also. It is difficult to say whether one variety is more severely affected than another ; but since some varieties are much more susceptible to foliage injury by lime sulphur than others, one would expect it to be so.

It has been suggested that the heavier fruit drop of the leader tipped trees may be due to their open and regular shape, and to the ease with which they are thoroughly sprayed. But this, I think, is hardly a feasible explanation. The untipped trees consist of two groups, one entirely unpruned, and the other thinned out and more or less spur pruned, but without any shortening of the leaders. One would naturally expect to find a similar difference between these two groups, since the " thinned out " trees are very much easier to spray thoroughly than the " unpruned." Yet this difference is not present. The thinned out trees normally set a somewhat higher percentage of their blossom than the unpruned, whether sprayed or not, and any difference does not specially favour the unsprayed trees. It has also been suggested that the position of the blossom trusses has some bearing on the result ; the blossom of the leader tipped trees is mainly in the centres of the trees, or at least some distance below the ends of the branches, whilst that of the untipped trees is largely on the tips, or near them (especially, of course, in the case of Worcester Pearmain). But here again there is a marked difference between the unpruned and thinned out trees ; the latter have a far larger proportion of their blossom in the centre of the tree, where it would receive the full force of the spray, and one would consequently expect to find on them a much heavier fruit drop as a result of lime sulphur spraying.

It is not at present possible to say whether the severity of the fruit drop varies with the severity of the leader tipping to which the trees are subjected. But since neither of the above suggested explanations of the heavier drop from tipped trees is quite satisfactory, it seems possible that it may be so. In any case, it seems certain that the use of lime sulphur as a summer spray on trees that are regularly severely pruned is more risky than on trees that are lightly or seldom pruned. A substitute is badly needed, especially for those varieties which are particularly subject to Bordeaux injury Our new series of fungicide trials is designed in part to throw light on this question ; but it has not progressed far enough as yet to allow of any satisfactory deductions.

Two suggestions may be made. It seems fairly certain that fungicides used at winter strength before blossoming will at least help to control scab, and possibly mildew. But they will probably not be effective alone in a season when scab is very prevalent. A substitute now used in America might be tried here—

" dry mix sulphur-lime,"—a mixture in a dry state of slaked lime, sulphur, and " calcium caseinate," the mixture being sifted into water and used as a wet spray. A preliminary trial of this mixture revealed the fact that Brandram's flowers of sulphur is not fine enough for the purpose; American writers recommend " superfine " sulphur, which appears at present to be unobtainable in this country.

Cumulative Effect.

In the first report a limited amount of evidence was presented indicating that some of the effects of fungicide spraying are cumulative, the effect of the fungicide on the tree extending beyond the season of application. The varieties used in our tests which showed this effect satisfactorily were but two, Worcester Pearmain and James Grieve; the sixty-four trees of each of these varieties allowed of a considerable multiplication of groups, for which the thirty-two trees of the other four varieties were too few.

Yet the other four varieties,—Allington, Cox's Orange, Bismarck, and Newton Wonder—are useful as showing the regularity of the result. When the trees of these varieties were divided into groups according to the fungicide applied in 1921, the fruit borne in 1921 was in almost every case more scabbed from those trees which had not been sprayed in 1920 than from those which had been sprayed. But since most of the groups consist of but two or four trees, the figures are hardly worth giving in detail.

With James Grieve the groups are larger, and the results more reliable. In 1921, twelve untipped trees sprayed in both 1920 and 1921, yielded 1,451 fruits, of which 7.8 per cent. were scabbed; whilst four untipped trees sprayed in 1921, but not in 1920, yielded 357 fruits, 19.9 per cent. scabbed. There is even some indication that the effect of the 1919 spraying still showed in 1921; compare, for instance, the twelve trees just mentioned (7.8 per cent. scabbed) all of which were sprayed in 1919 as well as 1920 and 1921, with twelve similar trees sprayed in 1920 and 1921, but not in 1919; the latter yielded in 1921, 1,313 fruits, of which 12 per cent. were scabbed. There is equally clear evidence that the effect of the 1920 spraying showed on the fruit produced in 1922 (in which year none of the trees of James Grieve were sprayed with fungicide). The same twelve trees mentioned above as having been sprayed in 1919, 1920 and 1921 bore in 1922, 1,588 fruits, of which 17.6 per cent. were scabbed; whilst the four similar trees sprayed in 1921, but not in 1920 produced 282 fruits of which 37.9 per cent. were scabbed. As will be shown directly, the trees of Worcester Pearmain fully bear out this third year's effect of the fungicide, and even extend it to the fourth year.

In 1921, the fruit of Worcester Pearmain was less scabbed than that of James Grieve, and the cumulative effect was consequently less obvious; the fruit

from fifteen untipped trees sprayed in both 1920 and 1921 was 6.9 per cent. scabbed, whilst that from nine similar trees sprayed in 1921 but not in 1920, was 9.3 per cent. scabbed.

In 1922, the fruit was still less scabbed than in 1921, yet the results on the untipped trees are fairly clear. Sixteen trees sprayed twice in 1921 and once in 1922 produced 3,213 fruits, of which only thirteen were scabbed, or about 0.4 per cent. ; whilst eight trees sprayed (once) in 1922, but not in 1921, bore 1,169 fruits of which forty-one were scabbed, or 3.5 per cent. It is interesting to compare with these figures the crop from eight trees sprayed in 1921 but not in 1922 ; these produced 2,527 fruits of which forty-one were scabbed, or 1.6 per cent. It seems from this that the two sprayings given in 1921 had more effect in reducing the scab in 1922 than the one spraying given in that year !

The crop from the same trees in 1923 was considerably more scabbed than in 1921 or 1922. In 1923, the trees were all sprayed with winter strength lime sulphur just before blossoming, and no fungicide of any kind was applied after blossoming. It became clear when the fruit was picked that the scab was largely confined to certain trees, but these seemed to bear no relation to the spraying done in 1922. It was not until the figures were completely analysed with reference to the spraying done in 1920, 1921 and 1922 that they could be understood at all. The results of this analysis are shown in Table III.

TABLE III.—CUMULATIVE EFFECT.

Worcester Pearmain, Crop of 1923.

	Sprayed all three years.	*Sprayed*	*Sprayed*	*Sprayed*
	1920 twice.	1920 twice.	1920 twice.	1920 *not at all.*
	1921 twice.	1921 twice.	1921 *not at all.*	1921 twice.
	1922 once.	1922 *not at all.*	1922 once.	1922 once.
Leader tipped	7 Trees.	8 Trees.	8 Trees.	9 Trees.
	1195 fruits.	1078 fruits.	1424 fruits.	1152 fruits.
	9 scabbed.	13 scabbed.	31 scabbed.	8 scabbed.
	=0.75%	=1.2%	=2.2%	=0.69%
Not tipped	7 Trees.	8 Trees.	8 Trees.	9 Trees.
	2443 fruits.	2691 fruits.	2652 fruits.	3237 fruits.
	33 scabbed.	122 scabbed.	330 scabbed.	188 scabbed.
	=1.3%	=4.5%	=12.4%	=5.8%

The figures for the leader tipped trees are given separately in order to show that even there, with only a few scattered fruits showing any scab at all, the influence of the 1922 spraying and still more that of the 1921 spraying,

can be seen. The figures for the untipped trees are, as usual, much more striking. We find that although the effect of the one spraying done in 1922 could actually be seen in 1923, the two sprayings done in 1921 had far more effect ; and even the two sprayings of 1920 had more effect in 1923 than the one of 1922.

It naturally occurs to one to enquire how many years this influence will last. An attempt to discover an effect on the scabbed fruit of 1923 from the spraying done in 1919 has led to no result, mainly because so very few trees have been treated in any one way since 1919. It seems not unlikely that had half of the trees been sprayed in 1919 and every year since, and the other half left unsprayed in 1919 but sprayed ever since, the proportion of scabbed fruits would have been higher in 1923 on the latter group.

The fact that the two sprayings given in 1920 and 1921 reduced the scab in 1923 more than did the one spraying given in 1922 (immediately after blossoming) suggests that the second spraying, three or four weeks after blossoming, is more concerned in this result than the first. No further data on this point are available ; we have never compared once sprayed with twice sprayed trees in the same season. But if it should prove to be so, it seems probable that a still later spraying might be even more effective.

It was suggested in the first report that the greater control of scab given by Bordeaux than by lime sulphur might possibly produce a similar though slighter effect in the following season ; figures were given showing an indication of this result. The data available for further study of this point are too scanty to be of much value, but as far as they go they seem to bear out the earlier figures. In the case of Newton Wonder, for instance, the eight untipped trees sprayed in 1921 with Bordeaux (6—20—100) bore, in 1922, 1,644 fruits, 4.5 per cent. scabbed ; whilst the eight trees sprayed in 1921 with ammonium polysulphide produced 1,376 fruits, 6.7 per cent. scabbed. For James Grieve the percentages of scabbed fruit in 1922 were : sprayed 1921 with Bordeaux (6—20—100), 22.1 per cent. ; sprayed 1921 with Lime Sulphur (1 to 59) with Arsenate, 25.9 per cent. For Bismarck the percentages in 1922 were : sprayed 1921 Lime Sulphur (1 to 29) with Lead Arsenate, 4.9 per cent. ; sprayed in 1921 with Ammonium Polysulphide 7.8 per cent. In the case of Worcester and Allington the only sprays used since 1919 were Lime Sulphur with and without lead arsenate or a spreader ; these differed so little in fungicidal value that one would hardly expect the difference to be carried over to a second year.

Whether or not the effect of one fungicide is carried over to a second year more than the effect of another, it is fairly safe to say that the cumulative effect is not confined to any one, but that all the fungicides tested do produce an effect extending beyond the year of application, and probably often into a second and third year.

Size of Fruit.

In the first report figures were given showing a probable influence of fungicides on the size of the fruit, the fruit of the sprayed trees having usually been larger, even where clean and scabbed fruits are taken separately. The data available for a further study of this point are somewhat contradictory. The only unsprayed trees available for comparison since the first report was published are those of Rival and Lord Derby in 1921, and of Worcester Pearmain in 1921, 1922, and 1923.

In 1921 the fruit of Worcester Pearmain (excluding as before the small undeveloped fruits) was distinctly smaller on the average on the unsprayed trees than on the trees sprayed with Lime Sulphur either alone or with Lead Arsenate. But in 1922 the result was reversed, the fruit from the unsprayed trees being on the average slightly larger than that from the trees sprayed with Lime Sulphur (with spreader). In 1923 the result was so irregular that no deductions can be drawn from it.

Rival and Lord Derby in 1921 also gave contradictory results, the tipped and untipped trees in each case being apparently affected in opposite directions.

The data for comparison of different fungicides give equally contradictory results, and it does not seem possible to draw from them any deductions whatever.

The results with Worcester Pearmain in 1921 and 1922 are, however, rather suggestive. In 1921 the fruit drop following the use of Lime Sulphur was comparatively slight, and, as noted above, the fruit was larger on the sprayed trees. In 1922, on the other hand, the fruit drop was very heavy, and the fruit was smaller on the sprayed trees, in spite of their much lighter crop. It seems possible that in this case, and perhaps in others also, the fruits which drop as a result of the application of Lime Sulphur include many of those which would, had the trees not been sprayed, have grown to the largest size. Here again very much more detailed work will be necessary to show what is really happening; it is hoped that our new tests will throw further light on the question.

Influence of Fungicides on Fruit Bud Formation.

The possibility of an influence of fungicides on fruit bud formation has been kept in mind; but unfortunately the available records are extremely scanty. It has never been possible to make even an estimate of the number of fruit buds on the pruned trees before pruning; the records show only those remaining after pruning. There remain the entirely unpruned trees; but only in one year was it possible to count the fruit buds of every tree; in the other years only representative trees were counted. The available records show that in every case the unpruned trees sprayed with Lime Sulphur, alone,

or in mixture with spreaders, etc., produced a larger average number of fruit buds per tree than the similar unsprayed trees. The only records available from unpruned trees sprayed with Bordeaux are those from Lord Derby in 1921, here the sprayed trees produced on the average less than half as many fruit buds as the unsprayed trees.

In spite of the uniformity of the result with unpruned trees sprayed with Lime Sulphur, one cannot feel any confidence in it. The " thinned out " trees, from which comparatively few fruit buds would usually be cut away, in several cases give the reverse result. The leader tipped trees, from which far more data are available, give a very variable result ; in 1920 and 1921 most of the trees sprayed with Lime sulphur showed a reduction in the number of their fruit buds, as compared with unsprayed trees; whilst in 1919 and 1922 an increase was more common than a reduction. It seems probable that where an increase is shown, this is primarily due to the fruit drop caused by the lime sulphur ; it is natural to suppose that if the crop is thinned soon after blossoming the tree will be better able to produce fruit buds.

Influence of Fungicides on Vigour of Growth.

In the first report mention was made of the greater stoutness of the one year shoots observed on the sprayed trees of Bismarck and Allington ; it was suggested that this might be reflected in the weight of prunings from these trees.

The weight of prunings has been recorded for every pruned tree throughout the trials. With very few exceptions it is greater from the sprayed trees ; the uniformity of the result, considering the great variability of the trees in size and vigour, is remarkable. The few instances where the weight of prunings was greater from unsprayed trees can be traced, with one exception to the fact that the trees not sprayed happened on the average to be considerably larger or more vigorous before the spraying was done. The one exception is Lord Derby, sprayed once with Bordeaux in 1921. Here the prunings from the leader tipped trees averaged 2 lb. 2 oz., where sprayed, and 2 lb. 6 oz. where not sprayed, a difference which cannot be accounted for by any difference in original size or vigour of tree.

It is conceivable that this apparent reduction in growth due to the action of Bordeaux on Lord Derby is connected with the very considerable leaf fall which followed the application of the spray. But this is not borne out by other cases where considerable leaf fall has been noted. The trees of Rival, for instance, sprayed with Lime Sulphur at 1 to 59 (also in 1921) suffered a very serious leaf fall ; yet the weight of prunings from the sprayed trees was distinctly greater than from the unsprayed, the difference being greater than could be accounted for by the very slight difference in average size of

tree. It might be suggested that Lime Sulphur has possibly a greater effect in increasing the weight of prunings than Bordeaux ; yet this is not borne out by those instances where both have been applied to different trees of the same variety. Worcester Pearmain, James Grieve, Newton Wonder, and Bismarck are all available here ; whilst the result is irregular, it is fairly clear that on the average the weight of prunings was heavier from trees sprayed with either Bordeaux or Lime Sulphur, than from unsprayed trees, and those sprayed with Bordeaux are certainly not consistently behind those sprayed with Lime Sulphur.

The fruit drop following the use of Lime Sulphur would perhaps account for any increase in growth—measured in weight of prunings—resulting from its application. But this will not account for the similar increase following the application of Bordeaux Mixture, for there had not, previous to 1923, been any indication of such a fruit drop, and in a good many cases the trees sprayed with Bordeaux have given a better set of fruit than unsprayed trees. The cause should more likely be sought in the control of scab, and possibly other fungi, on the leaves ; it has often been noticed that the leaf fall of the sprayed trees is later than from the unsprayed trees.

The data on tree measurements such as extreme height, extreme spread, and girth of stem below the branches, do not give any clear indication of the influence of the fungicides, one way or another. The trees vary so much more in size than in the weight of prunings cut from them, that the number in any one group is not large enough to give any figures of value. Had the same trees been sprayed, and the same ones left unsprayed, year after year, the final percentage of increase in their dimensions might have served to indicate possible influences of the fungicides on growth ; but no trees have been left unsprayed for longer than two years in succession, and very few for more than one year.

SUMMARY.

In this report an attempt is made to analyse in detail the effects of certain fungicides on apple trees. It is shown that while they have the expected fungicidal effect, their influence is by no means confined to this, but includes certain effects some of which may be regarded as beneficial, whilst others are undoubtedly injurious.

The deductions drawn are as follows :—

1. All the fungicides used throughout the tests have reduced the attacks of scab (*Venturia inæqualis*).

2. Bordeaux mixture (at 6—20—100) controlled scab almost as effectively as Lime Sulphur (at 1 to 59) and more so than Ammonium Polysulphide.

3. Of the fungicides used Bordeaux (6—20—100) was the least effective against Apple Mildew (*Podosphæra Leucotricha*); Lime Sulphur was somewhat more effective than a brand of Ammonium Polysulphide (not the same brand as mentioned in the first report).

4. The fungicides used in 1920 clearly reduced the number of canker (*Nectria ditissima*) infections of Worcester Pearmain and James Grieve in the Winter of 1920-1921.

5. Bordeaux (6—20—100) was found to cause considerable russetting of the fruit of James Grieve and Newton Wonder, and very much of Lord Derby.

6. Lime Sulphur used as a summer fungicide has repeatedly caused a heavy fruit drop from trees of all varieties tested. The fruit drop is much heavier from leader tipped than from untipped trees.

7. The effect of fungicides is by no means confined to the season of application. In several cases it can be seen (in the proportion of scabbed fruit) one and two years later, and in one case, three years later.

8. The influence of fungicides on the size of the fruit, if any, is contradictory, and no clear deductions can be drawn from these tests.

9. The fungicides may in some cases have caused an increased formation of fruit buds, but this may be only a natural sequence from the fruit drop caused by Lime Sulphur.

10. Vigour of growth, as measured by weight of prunings, appears in nearly all cases to be increased by fungicide spraying. This is not solely due to the fruit drop caused by lime sulphur, since it follows the use of Bordeaux Mixture also.

EGG KILLING WASHES.

By A. H. LEES, M.A.

Long Ashton.

The experiments described below are a continuation of work done during the Winter of 1922 and published in the Annual Report for 1923 of the Agricultural and Horticultural Research Station, Long Ashton. This work showed that certain substances were capable of reducing the hatch of *Aphis pomi* (Permanent Apple Aphis) to under 1 per cent. against control hatches of 2.4, 7.2, 17.5 and 25.3. While the figures for hatching of controls were too variable to be satisfactory there was clear evidence that in these experiments Lime Sulphur and some coal tar products had very marked killing action. The trials were therefore continued in the Winter of 1923 and a special attempt was made to eliminate some of the probable sources of error.

The writer is much indebted to various Inspectors of the Ministry of Agriculture for securing supplies of eggs, and to his colleague, Mr. E. Ballard, for manipulative assistance.

PROCEDURE.

The eggs selected for the trials were those of the Permanent Apple Aphis, *A. pomi*. These eggs can be obtained generally in large quantities and the young trees, mostly maidens or two-year-olds were grown in pots. This method enabled the trials to be carried out under conditions approaching as far as possible to natural conditions in the field.

Each fluid to be tested was sprayed, not painted as in 1922, on to a single long twig covered with eggs. Untreated twigs were left occasionally as checks. Care was taken that no spray fluid reached any neighbouring twigs on a tree that were to be tested with a different fluid.

In 1922 some of the controls and treated portions showed an unexpectedly low hatch and it appeared probable that this was due to the fact that such eggs were exposed to a laboratory temperature for two or three hours. It has been shown that aphis eggs, if subjected to room temperature in winter are very apt to die. To avoid this possibility, therefore, the trees were sprayed outside in fine weather or in a cold greenhouse in wet weather. They were not exposed to rain and weather until the spray fluid was dry, but after this was accomplished they were placed in an unsheltered position.

As soon as hatching began the trees were removed inside and laid over oiled paper. The young larvæ on emerging from the egg seem to find considerable difficulty in preserving a foothold and usually fall on to the paper. In this position they can be counted at leisure. After hatching was finished and all

counts made the twigs were cut into sections and the empty egg shells and unhatched eggs separated by hot caustic soda. The number for each treatment was then estimated by counting six separate aliquot portions.

RESULTS.

Controls.

The percentage of hatch for the six controls used during the whole experiment were 15, 26, 26, 30, 40, 43, or an average figure of 30.5. These figures are much higher than those obtained in 1922 and point to the probability of the experiment being done under more natural conditions. No doubt a certain number of larvæ were lost before the trees were removed inside for counting. It was unfortunately impossible to find sufficient room under cover and under proper conditions to make the move early enough to preclude this possibility.

For convenience of consideration the various substances tried may be divided into a few groups.

The first group consists of various sulphur bodies of which Lime Sulphur is the most important.

Table I.—Sulphur Group.

Per cent Hatch.

	Alone.		With .2% Calcium caseinate.	
	Applied Feb. 20th.	Applied Mar. 19th.	Applied Feb. 20th.	Applied Mar. 19th.
1 in 15	7	7	.07	.55
1 in 20	3	9	.5	.7
1 in 30	12	0	.55	.9
1 in 60	20	—	20.0	—
Sulphur fumigation ..	26			
Sulphaqua 1 in 500 ..	8			
1 in 1,000	13			
	43			
Hypo. 5%	29			
Hypo. and HCl. ..	18			
Sulphur Paste	15			

The lowest number of eggs used in the Lime Sulphur treatments was 246, the highest 4,666 and the average 2,059.

The figures for Lime Sulphur applied alone at all strengths and times are comparatively high. It may be taken that unless a fluid gives a percentage hatch of below one it has but little value for commercial purposes. The rate of multiplication of aphids is so high that any figure higher than one would give in practice but a poor control. In the 1922 results, figures below 1 per cent. hatch were obtained but the 1923 figures are more in accord with the frequent unreliability of Lime Sulphur for egg killing purposes which has been the experience of commercial growers. There are two possible reasons for the

discrepancy between the 1922 and 1923 figures. The first is that the 1923 controls gave a higher hatching figure, which suggests that in 1922 there may have been some other anti-hatch factor present beside the wash used. The second and probably more important reason is the different method of application. In 1922, the Lime Sulphur was brushed on, in 1923 it was sprayed on. Lime Sulphur has rather poor wetting powers and the extra contact made by brushing over spraying may serve to explain the difference obtained in the two years. That this explanation is probably correct is indicated by the figures given for the various strengths of Lime Sulphur when used with the addition of .2 per cent. Calcium caseinate. Calcium caseinate increases the spreading power and probably the wetting power and a very marked change in the percentage hatch figures are shown.

With the exception of the strength 1 in 60 all strengths tried show a hatch of under 1 per cent. On the whole the higher strengths show slight superiority and the same applies to the earlier date. Those differences though consistent are not of such magnitude that undue stress should be laid on them. The chief point brought out is the very large difference made by the addition of Calcium caseinate. It would thus appear that a higher strength than 1 in 30 is unnecessary and should this result be confirmed by further trials it would appear that Lime Sulphur could be used as a cheap and reliable aphis egg-killing wash for Winter work.

The lower part of Table I. shows the effect of various other sulphur containing fluids. Fumigation by sulphur vapour had no appreciable effect. Sulphaqua, a proprietary body giving off sulphur dioxide and finely divided sulphur, had a slight effect at the higher strength and so possibly had sulphur paste, and "hypo" and hydrochloric acid. On the whole however there was nothing to indicate that either finely divided sulphur or sulphur dioxide had any appreciable effect. This fact seems to suggest therefore that the action of Lime Sulphur must be looked for in its polysulphide content.

TABLE II.—NICOTINE-SODA GROUP.

Per cent. Hatch.

Caustic Soda. %	Nicotine. %	Feb. 20th.	March 19th.
2	.05	3	0
2	.025	4	.05
2	.012	22	—
1	.1	—	0
1	.05	17	—
1	.025	21	.16
1	.012	—	.54
—	.05	22	11.0
—	.025	—	27.0
—	.012	44	13.0

The lowest number of eggs used per treatment was 120, the highest 5,533, and the average 1919.

The original idea in testing mixtures of caustic soda and nicotine was that the action of the soda might prepare the way for the entry of the nicotine. It was not probable that either substance by itself was likely to be effective but the combination might. The 1922 results were inconclusive but suggested that there might be some action.

Table II. shows that for the February date and for most of the strengths tried the mixtures were useless. Two per cent. soda combined with .05 per cent. and .025 per cent. of nicotine did however considerably reduce the hatch. For the March date all combinations of soda and nicotine caused marked reduction of hatch bringing it below 1 per cent. In all these cases a slight damage to the terminal bud was caused owing to the fact that it was already swelling. No permanent damage was done however. Nicotine by itself without soda proved ineffective at all strengths though slightly more killing than when tried in February. The addition of caustic soda considerably increased killing power as may be seen by comparison of different strengths of nicotine in the February treatments. Thus for strength, .012 nicotine, no soda gave 44 per cent. hatch, 2 per cent. gave 22 per cent. For .025 per cent. nicotine, 1 per cent. soda gave 2.1 per cent. hatch, 2 per cent. gave 4 per cent. hatch. For .05 per cent. nicotine, 1 per cent. soda gave 17 per cent. hatch, 2 per cent soda gave 3 per cent. hatch. From these facts it is clear that caustic soda nicotine might have a commercial use under certain circumstances. Thus when an orchard is especially overgrown with epiphytes or mussel scale has to be dealt with, by delaying the spraying as late as possible and adding .025 per cent of nicotine an ordinary caustic soda spraying might be made very much more effective against insect eggs.

Table III.—Coal Tar Group.

Per cent. Hatch.

% Strength.	10	7	5	4	2½	2	1
Substance :							
A under 215°C.	1.4	7.0	—	52.0	—	—	23.0
B 215°C.—230°C. ..	5.0	6.0	—	15.0	—	—	22.0
C Total under 300°C. ..	5.0	5.0	—	22.0	—	—	15.0
D Total Distillate ..	.06	.3	—	8.0	—	—	38.0
E.	6.0	5.0	—	27.0	—	—	31.0
F.	—	—	—	30.0	—	31.0	49.0
G Pyridene	18.0	—	26.0	—	10.0	—	—

The lowest number of eggs used per treatment was 230, the highest 4,850, and the average 1,361.

In this Table A—D are preparations made from a gas works distillate, A being the fraction boiling under 215° C., B that between 215° and 230° C., C the total distillate boiling under 300° C. and D the whole distillate. E—F are proprietary fluids.

The portions A—D were combined with soap to form emulsions and tested at the strengths shown in the table. The only fractions showing any marked killing power are 10 per cent. of A, and 10 per cent. and 7. per cent. of D. It is hoped to follow up the indications given by these figures in future trials.

E and F were proprietary preparations and the figures given call for no comment.

It is clear from these figures that coal tar derivatives derived from gas works products only give very variable results. Many substances have no useful action, some are directly dangerous and some appear to be very useful. The trials however are yet at too early a stage to allow of any definite conclusions being drawn.

Conclusions.

(1) Working with the eggs of *Aphis pomi* it was found that Lime Sulphur at all strengths by itself was ineffective.

(2) Lime Sulphur with the addition of .2 per cent. calcium caseinate had a strong killing action at the strengths of 1 in 15, 1 in 20, and 1 in 30, whether applied in February or March.

(3) Other fluids releasing or containing finely divided sulphur or sulphur dioxide were comparatively ineffective.

(4) Combinations of caustic soda and nicotine had strong killing power if applied just before hatching but were useless at an earlier date.

(5) Certain of the coal tar products were toxic but most of them were inoperative and some damaging to the plant.

TRIAL OF SPRING CABBAGES (AUTUMN SOWN) 1922-1923.

A. D. TURNER, N.D.Hort.
(*Horticultural Superintendent, Somerset County Council.*)

In the Autumn of 1922, a small demonstration trial of Spring Cabbage was arranged in the Somerset Farm Institute Gardens, at Cannington, near Bridgwater, as part of the scheme to make the gardens as educational and practical as possible. The Autumn sown crop of cabbages is an important one on market gardens, farms, allotments, and private gardens, and usually is of good value.

Success with this particular crop depends upon a number of factors, some of which can be controlled to a certain extent by the cultivator, while others are natural circumstances which, although beyond control, can be prepared for to some degree by information upon the subject.

Chief among the cultural details are :—

(*a*) The selection of a variety suitable to the district, soil and market requirements.

(*b*) The purchase of good seed raised from good stock carefully rogued.

(*c*) Sowing the seed at a time suitable to the average weather conditions of the district.

(*d*) Planting out within a reasonable time of sowing in order to get the plants established but not grown too large before Winter.

(*e*) A condition of the soil which will maintain very steady growth during Autumn, but which will provide rapid growth and hearting as early as weather conditions will allow in the Spring.

A badly managed crop may be a loss to the cultivator, first in not coming sufficiently early to realise the best prices which in normal seasons are for the first cuttings, and second, in not being all ready for the market within a reasonable time. In the latter instance a crop which remains in the ground until June before cutting is completed may mean a loss as the land cannot be easily cropped again for the Summer, but where the majority of heads can be cut by the middle or end of May, other crops such as Beet, Celery, Turnips, Carrots and Runner Beans could be worked in and no time lost. Good seed of suitable varieties will largely assist the grower in getting his crops cleared reasonably early and as the stocks of seeds of the same variety may vary, a great deal, it is very important that only good type seeds are used.

The trials under view were arranged to demonstrate several of the factors of cultivation which are of importance, the best stock of seeds obtainable were used and no attempt was made to vary the soil treatment or the system of manuring.

VARIETIES.

Twelve varieties were selected which are in general commerce and favoured by growers for one purpose or another, with the object of comparing their growth and qualities under the same conditions.

SOWING.

The date for sowing cabbage seed has long been recognised as a very important factor in the production of an early and useful crop ; the actual time being found to vary in different parts of the country from July 15th in the north, to August 30th in the South, the average date being about August 15th. Experience shows that a too early sowing in a district where up to the end of the year the weather is open and mild, will result in the plants becoming too large and soft in growth and be unable to stand the Winter, or if they do winter fairly well, many varieties will " bolt " to seed instead of hearting. On the other hand, a too late sowing may give plants which are not sufficiently advanced to commence growth and hearting and as soon as warm Spring weather occurs, or which may rush unto rank growth and be delayed in hearting.

The trials were arranged to demonstrate the results obtained by varying the dates of sowing and getting the plants into permanent quarters.

Taking August 15th as approximately the best sowing date, one batch of seed was sown on July 31st, or fifteen days too early, and a second batch was sown on August 21st, or five days too late. A late sowing was not made, as the risk of loss of crop was too great. From these sowings, planting was done at three periods, as follows :

Sown, July 31st, 1922	Group 1.	Planted September 22nd, 1922 (as soon as plants were ready).
	Group 2.	Planted October 10th, 1922.
Sown, August 21st, 1922	Group 3.	Planted October 16th, 1922 (as soon as plants were ready).

The land upon which the demonstration was made had been dug in early Spring and a crop of early carrots taken off. No special preparation was made for the cabbage crop beyond a deep hoeing to incorporate a dressing of fish guano at the rate of 4 cwts. per acre. Planting was done at two feet between the rows and 1½ feet between the plants in the rows. Frequent surface cultivation was given during late Autumn and early Spring. When the plants showed signs of new growth in the middle of March, a dressing of equal parts of Sulphate of Ammonia and Superphosphate (35 per cent. soluble) at the rate of 1½ cwts. per acre was given ; a second application of this mixture was given after an interval of a month.

RECORDS OF THE CROPS.

No definite standard of maturity was fixed as to when the cabbages should be recorded as ready, the crop was marked at weekly intervals and all those

heads which were fit for market were cut. For the purpose of reporting results, 100 plants of each variety in each group were used for recording and notes taken of the dates of cutting. As the value of a cabbage lies in its earliness and the time at which the land can be cleared, records of cutting were taken only for the first four weeks.

All those heads not ready for market within one month from the date of cutting were, for this purpose, treated as "rogues," or not true to type, although the majority of these late plants were eventually used.

The following tables give a summary of our records:

GROUP 1.

Sown: July 31st, 1922. Number of plants recorded: 100.
Planted: September 22nd, 1922.

Variety.	Date of first cutting.		Weeks in cut and number.				Failures.	Rogues. and Late.	Average Dimensions in inches.	Remarks.
	Mth.	Day.	1	2	3	4			Ht. Dia.	
April ..	May	17	17	5	—	—	9	69	8×10	Irregular.
Chardonian ..	April	13	11	43	—	—	10	36	11×14	Mixed.
Early Market ..	,,	6	19	22	24	—	5	30	9×14	Good.
Ellam's Early ..	,,	6	27	12	41	4	13	3	12×13	Good.
Emperor ..	,,	13	35	5	18	26	7	9	12×12	Very Good.
Favourite ..	,,	13	18	8	46	—	13	15	9×10	Good.
Flower of Spring	,,	6	23	3	55	15	3	1	11×14	Very Good.
Harbinger ..	,,	6	21	6	26	—	9	38	8× 9	Small, bursting.
Imperial ..	,,	6	21	46	9	—	7	17	12× 2	Fair.
King of West ..	,,	12	10	40	—	—	3	47	11×11	Coarse, mixed.
Mein's No. 1. ..	,,	13	30	6	32	16	10	6	11×14	Good.
Offenham ..	,,	9	25	47	13	—	12	3	11×14	Very good.

GROUP 2.

Sown: July 31st, 1922. Number of plants recorded: 100.
Planted: October 14th, 1922.

Variety.	Date of first cutting.		Weeks in cut and number.				Failures.	Rogues and Late.	Average Dimensions in inches.	Remarks.
	Mth.	Day.	1	2	3	4			Ht. Dia.	
April ..	May	7	26	15	24	27	3	5	8×12	Good.
Chardonian ..	,,	17	3	5	13	13	29	37	10×13	Mixed.
Early Market ..	,,	17	3	12	21	16	11	27	9×12	Very fair.
Ellam's Early ..	,,	17	6	9	9	17	5	54	11×13	Good.
Emperor ..	,,	24	3	18	4	20	7	48	10×14	Poor grade.
Favourite ..	,,	17	3	5	4	9	6	73	10×12	Fair, small.
Flower of Spring	,,	12	17	25	8	10	1	39	10×10	Fair.
Harbinger ..	,,	19	7	13	12	10	8	50	8× 9	Small.
Imperial ..	,,	18	16	12	13	15	5	39	10×14	Good grade.
King of West ..	,,	17	0	30	—	—	7	57	10×10	Late, mixed.
Mein's No. 1 ..	,,	19	20	2	23	25	3	27	11×13	Burst heads.
Offenham	,,	17	37	7	24	7	15	10	10×14	Good.

GROUP 3.

Sown: 21st August, 1922. Number of plants recorded: 100.
Planted: October 16th, 1922.

Variety.	Date of first cutting.		Weeks in cut and number.				Failures.	Rogues and Late.	Average Dimensions in inches. Ht. Dia.	Remarks.
	Mth.	Day.	1	2	3	4				
April	May	17	54	15	7	10	5	9	14×14	Good.
Chardonian.. ..	,,	17	31	12	14	—	6	37	14×22	Very mixed.
Early Market ..	,,	17	45	7	14	13	7	14	12×14	Burst heads.
Ellams Early ..	,,	17	13	14	10	6	5	52	12×13	Burst heads.
Emperor ..	,,	17	20	14	23	4	5	34	14×17	Coarse and large.
Favourite	,,	17	9	14	6	10	7	54	12×14	Various sizes.
Flower of Spring	,,	17	10	—	—	—	31	59	11×18	Various sizes.
Harbinger	,,	17	24	4	11	20	14	27	10×16	Burst heads.
Imperial	,,	17	20	9	7	14	31	19	10×14	Poor grade.
King of West ..	,,	17	17	20	13	—	14	36	12×13	Very mixed.
Mein's No. 1. ..	,,	17	38	15	6	11	14	16	10×15	Good heads.
Offenham	,,	17	17	13	10	7	6	47	18×14	Fair.

With a crop of cabbages it is much more difficult to record and interpret results than it would be crops such as Potatoes, which can be dug and weighed on one day, consequently the above tables at first appear to be rather complicated. The chief items in the table are the dates of first cutting, the proportion of the crop cut during the first four weeks, and the number of late plants. The variation in the number of failures, too, makes comparisons very difficult, these failures indicate all plants which failed to grow to any semblance of a Cabbage by the first cuttings date. Such plants may have resulted from weak seed or damaged in planting or hoeing, or some of them may have been a type of "rogue" or wilding.

In Group 1 the best variety was "Flower of Spring." It cut early and cleared early, with only four heads out of the hundred as waste. Following this variety in Group 2, the late planting would appear to be against it, as forty out of the hundred were not cut. In Group 3, late sowing seems to be much against this variety, as ninety out of the hundred were not used. Similar results are shown with the varieties: "Offenham," "Ellam's Early," "Emperor," and "Imperial," four of the most popular varieties grown. "Mein's No. 1," also a very good variety, does not show these extremes of variation, neither does "Early Market," and if this feature is consistent, it might be a special recommendation to these varieties for field culture where conditions of cultivation are somewhat rougher.

The variety "April" is usually quick in maturing and on good land, particularly in private gardens, it is one of the best, but from records it seems

that early sowing and early planting is not advisable as the late planting from the early sowing and also the late sowing gave the best results. In connection with this variety, it may be interesting to note that the surplus plants left over in the seed beds from August, 1922, sowing were planted out at the end of March, 1923, and have a better grade of cabbage ready for cutting on June 12th, 1923. With the exception of "Flower of Spring," several other varieties tested in this way did not give such good results.

"Emperor," a good heavy market variety demonstrated more clearly than any other variety the importance of not delaying the sowing and planting out of the Cabbage Crop. In Group 1, it came very true to type and looked to be the best variety in the whole set, it hearted quickly, was a bright colour, tender and of first-rate flavour when cooked. In Group 2, it could be scarcely recognised as the same cabbage, being smaller, stunted, irregular in hearting, tough in texture and strong flavoured when cooked. In Group 3 its appearance was again very different from that of Group 1. It was much larger, rank and soft in growth, slow in hearting and weak in flavour.

"Harbinger" generally considered as a variety for private use rather than for market and requiring richer soil, was disappointing in the trials on account of its smallness and determination to form a heart; it was best in Group 3, but not large enough for rough market trade.

SUPPLEMENTARY TRIAL AT STREET.

As the soil at the Institute gardens is scarcely representative of the soils of the county, being gravelly, lacking in organic matter and generally poor, a small trial of Cabbages from the Institute seed beds was made at Street. There the soil is a Lias Clay, fine in texture, very stiff and heavy, and almost directly opposite to the soil of the gardens. Actual comparisons with our trials at the Institute cannot be made, as it was not possible to set up the demonstration trial to the same extent or in the same manner, but the following record will illustrate how easily a cabbage crop is influenced by local conditions.

In this table, if compared with Group 3 table, it will be noticed that the plants grow much larger dimensions on a stronger soil, and that the time of cutting has also been delayed by exuberant growth. "Harbinger" and "Early Market" were the most satisfactory; "Flower of Spring" came third in favour, "Ellam's Early" did not heart up at all well; "Emperor" "Offenham" and "Favourite" did not finish until mid-June, and too late to allow another Summer crop to follow.

DEMONSTRATION OF VARIETIES AT STREET, SOMERSET.

Sown: August 21st, 1922. Number of plants of each variety, 20.
Planted: October 20th, 1922.

Variety.	Date of Cutting.		Not true to type.	Average Dimensions in inches.	Remarks and Observations.
	Mth.	Day.	Rogues.	Ht. Dia.	
April	May	12	2	10×11	Small, not very regular.
Early Market ..	May	5	—	15×20	Good compact heads.
Ellam's Early ..	May	20	4	16×16	Compact but long stems.
Emperor	June	—	3	15×20	Rather open, not leafy or spreading.
Favourite ..	June	—	7	14×20	Loose, spreading poor.
Flower of Spring ..	May	14	3	16×16	Very good, two burst heads.
Harbinger	May	8	4	12×10	Large for variety, compact.
Imperial	May	12	3	12×10	Small, even compact heads.
Mein's No. 1 ..	May	12	3	14×15	Very even.
Offenham	June	—	4	15×21	Spreading, very leafy.

This small trial at Street illustrates the importance of such trials on local soils as a more reliable guide to the choice of varieties suitable to a particular district, and it demonstrates that at least three of the most popular varieties may be useless on a heavy soil in a late district unless sown and planted at the proper date for the district.

The trials both at the Institute and at Street served a very useful purpose as they have been used by the Staff for teaching purposes and for demonstration to visitors and pupils visiting them.

Further, it is hoped that this report will be of some service as an illustration that more than ordinary care and attention is required to obtain serviceable crops of Spring Cabbages and that, providing a suitable variety can be decided upon for a locality, if sown and planted within reasonable time, good returns may be realised.

NOTES ON THE POLLINATION OF CHERRIES
APPLIED TO COMMERCIAL CHERRY GROWING.

By CECIL H. HOOPER.

The following notes are based on my own pollination trials with cherries in 1912, 1913, 1914, 1919, 1922, and 1923; also on observations as to the cropping of certain Cherries with other varieties made by the late Mr. G. P. Berry and myself.

The varieties are placed in comparative approximate order of flowering.

EARLY FLOWERING.

First day. Corone or Caroon, a small late black Cherry, an old variety, not recommended to be planted, apparently self-sterile. Early Rivers crops well near this variety.

Seventh day. Circassian, is apparently slightly self-fruitful, black when dead ripe, and picked after Early Rivers and Baumann's May. With Amber Bigarreau in one orchard it is said to crop badly. In pollination trials with pollen of old Kentish Black it set plentifully and matured good fruit; with Early Rivers it also matured good fruit.

Malling Eagle flowers about the same time as Circassian. This variety fruits badly in an orchard planted with Napoleon. A variety is needed to be chosen to re-graft a proportion of trees in this orchard to ensure satisfactory cross-pollination.

Eighth day. Early Rivers. As the result of many trials this variety has always shown itself self-sterile; it matures fruit with pollen of many varieties, but with some better than with others. This is perhaps the most valuable variety of cherry, but it needs to be planted with one or more early flowering varieties. Mr. G. P. Berry, late General-Inspector in Horticulture of the Ministry of Agriculture, recommended Baumann's May and Goodnestone Black from orchard observation and pollination trials as good varieties to plant with Early Rivers. I have myself seen good crops on Early Rivers adjoining Baumann's May in orchards at Selling and Wye, also in my pollination trials Early Rivers matured good fruit with Baumann's May pollen. Baumann's May has the advantage of being fit to pick about the same time or shortly after Early Rivers, which it resembles in appearance but is less sweet. In my pollination trials the varieties of pollen with which Early Rivers matured good fruit were Elton, Black Heart, Waterloo, Baumann's May, Amber Bigarreau, Black Eagle, Florence, Turk, Governor Wood, Black Tartarian, Circassian, but Early Rivers did not mature with pollen of Napoleon, Knight's Early Black,

Morello, Kentish Red, May Duke or Bedfordshire Black; but as the number of trials with these was few, in some cases only one, they might be successful if tried again, especially as Mr. Berry found an orchard at Wisbech of Early Rivers and Knight's Early Black in equal proportion, with good crops on both varieties. In another orchard Mr. Berry found that where Early Rivers was planted with Napoleon, Early Rivers hardly fruited at all. Early Rivers fruits well near Corone, Circassian and Old Black Heart, but none of these would now be recommended for commercial planting. With regard to Bedfordshire Black, this variety had better not be planted with Early Rivers, because Mr. Crane finds at the John Innes Horticultural Research Station that Early Rivers and Bedfordshire Black are inter-sterile.

Baumann's May is early flowering. It is apparently self-sterile, but is a good cropper with other varieties. It is a good pollenizer for Early Rivers, it matures its fruit nearly as early, is a strong grower and makes a well-shaped tree. In pollination trials it matured good fruit with pollen of Early Rivers, Knight's Early Black and Turk, which all flower about the same time.

Elton Heart. This extremely nice dessert Cherry sometimes does not make a very robust tree and often fruits rather sparingly. Elton appears to be quite self-sterile. In many orchards it appears to crop fairly well with Early Rivers, and several experienced growers recommend these as good varieties to plant together, the Elton blossoming at about the same time or slightly later. In my pollination trials the best results with Elton were with the pollens of Knight's Early Black, Black Eagle, Monstreuse de Mezel, Early Rivers and Frogmore; less well with pollens of Napoleon, Amber Bigarreau and Victoria Black. Elton failed to mature fruit in one trial each with pollens of Turk, Circassian, May Duke, Cluster and Crown. In an orchard planted with Cluster, Knight's Early Black and Amber Bigarreau, it does not crop well; in another orchard with Roundel, Frogmore and Amber Bigarreau it also crops badly.

Turk. This useful black Cherry flowers relatively early, but its fruit matures quite late. It is to a small degree self-fruitful, but crops badly when planted alone. It apparently crops better interplanted with some varieties than with others. In pollination trials good fruit matured with pollens of Elton, Early Rivers, Governor Wood, Circassian, Napoleon, Frogmore, Amber Bigarreau, Knight's Early Black, and last and least well with Waterloo, but these results are only from a few or single trials. It has been suggested that Turk and Elton be planted on the lighter soil of a farm to avoid damage of their blossoms by frost.

Governor Wood is apparently self-sterile. In one orchard planted with Elton it was bearing a heavy crop; in another orchard interplanted with Napoleon both varieties were reported as cropping well and regularly. In

one record of two acres planted with Governor Wood without other variety it was stated to be fruiting well. In my pollination trial with pollen of Knight's Early Black good fruit matured.

Tenth day. KNIGHT'S EARLY BLACK occasionally but rarely matures fruit with its own pollen ; it seems generally to fruit well among other varieties. I have not made many pollination trials with this variety. Good fruit matured with pollens of Waterloo, Baumann's May, Black Eagle and Napoleon, but in single trials failed to mature fruit with Elton, Early Rivers, Old Kentish Black and Circassian.

MID-SEASON FLOWERING.

Eleventh day. VICTORIA BLACK. From one year's pollination trials this variety appears to be sometimes self-fruitful to a considerable degree. From one bag, the flowers of which were pollinated with Frogmore, fifteen fruits matured ; from one bag two fruits matured with Elton pollen ; from one bag one fruit matured with pollen of May Duke.

BLACK EAGLE is apparently self-sterile. I have not been very successful with the few pollination trials I have made with this valuable variety. With pollen of Knight's Early Black good fruit matured. In one orchard where this variety is planted alone in a large block there is very little fruit ; in another orchard where it is planted with Turk this variety fruits splendidly.

Thirteenth day. ROUNDEL or RUNDLES is apparently self-fruitful to a very small degree. In pollination trials pollen of Amber Bigarreau matured very good fruit, but in single trials of the pollens of Early Rivers, Elton, Waterloo, Old Kentish Black and Frogmore fruit failed to mature. Roundel is a valuable variety which, like many other kinds, fruits most heavily at the tops of the trees.

Fourteenth day. FROGMORE is considered a valuable and regular bearer. It appears to be self-sterile or rarely to mature fruit with its own pollen. In my pollination trials it fruited best with Amber Bigarreau, Turk, Governor Wood and Roundel, also with Black Tartarian, Early Rivers and Waterloo ; it failed, however, to mature fruit with the pollens of Napoleon and Knight's Early Black, but as these were only single trials in each case, these pollens need to be tried again before saying these varieties are not good pollenizers for Early Frogmore Prolific.

WATERLOO seems somewhat particular as to soil or surroundings as in some places it thrives and fruits well, but in some orchards it is not successful. It is generally considered the nicest late dessert black Cherry. It is self-sterile. From orchard observation and from pollination trials, it is found to crop well with Amber Bigarreau ; their flowering and picking seasons are about the same time. In one orchard where Waterloo is intermixed with Circassian, Waterloo crops

well. In my pollination trials good fruit matured with the pollens of Amber Bigarreau, Black Tartarian, Governor Wood, Napoleon, Baumann's May, Turk and Flemish Fruit failed to mature with the pollens of Frogmore, Morello, Elton, May Duke, Early Rivers, Bedfordshire Black and Cleveland Black, but these were in most cases only single trials with pollen of each variety, and circumstances may not have been favourable.

NAPOLEON is for practical purposes self-sterile, as only once out of my many trials has good fruit matured when the flowers were self-pollinated. This variety seems somewhat particular as to its pollenizer, as orchards were observed in which Napoleon cropped well severally with May Duke, Webb's Black and Governor Wood, but in another orchard where Napoleon is planted with Malling Eagle, neither variety cropped well, though both were fine healthy trees. In pollination trials good fruit matured with the pollens of Knight's Early Black, Amber Bigarreau, Black Eagle, Waterloo, Frogmore, Florence, Turk, Morello, but fruit failed to mature with pollens of Cluster, Early Rivers,Black Tartarian, Roundel and Kentish Red, as these latter, however, were only with one trial each, no special note should be taken of them, as there may be error. Nevertheless as one leaf may show the way the wind blows, I would prefer to choose to plant with this variety one which had shown itself a successful pollenizer, until this variety has been more fully tested.

LATE FLOWERING.

Fifteenth day. AMBER BIGARREAU or KENTISH BIGARREAU. This variety is very widely grown ; it makes a fine tree and will live under favourable conditions to one hundred years. It is nearly self-sterile ; occasionally but rarely it matures good fruit with its own pollen. It does not crop well in all orchards, especially where planted alone. Orchard observation and pollination trials show that it fruits well with Frogmore. In an orchard of Amber planted with Cluster, both varieties fruited well. In an orchard with Black Eagle, Turk and Elton it fruits well yearly, but in another orchard on the same farm with an occasional tree of Victoria Black and Napoleon it fruits badly. Amber and Frogmore certainly fruit well together ; also it appears to fruit well and regularly with Governor Wood or Waterloo ; but planted with Circassian, both varieties crop badly.

In my pollination trials, the best results have been with Frogmore, next in order with Turk, Napoleon, Waterloo, Flemish and Kentish Red Preserving, then with Black Heart and Crown. Fruit failed to mature in one trial each with pollens of Early Rivers, Elton and Governor Wood, although the crop on the tree was splendid. Once out of many trials it matured fruit with its own pollen (in 1922).

CLEVELAND appears to flower about the same time as Amber Bigarreau, also CLUSTER, but the time of flowering of this latter variety needs more observation ; it may commence to flower considerably earlier. Cluster is a late Cherry, and appears to crop well when planted next Amber Bigarreau.

FLORENCE appears to be slightly self-fertile occasionally. It is a valuable late variety somewhat resembling Napoleon ; it generally fruits well. In pollination trials Amber Bigarreau proved to be a good pollenizer (with four and six fruits maturing from two bags), also Napoleon, Early Rivers and May Duke, but fruit failed to mature in single trials with Elton, Morello and Wye Morello.

LATEST TO FLOWER.

Nineteenth day. MAY DUKE is found at the John Innes Horticultural Research Station to be self-fruitful to the extent of about one fruit to a thousand flowers ; in my own trials I have not yet found fruit mature with its own pollen.

FLEMISH is self-fruitful to a considerable extent sometimes, thus four bags left unpollinated by hand matured eleven fine fruits, but flowers of five bags pollinated with own pollen failed to mature any fruit ; pollen of Kentish Red Preserving did not mature fruit.

Twenty-first day. MORELLO. There seem to be three varieties of Morello, the small Wye Morello, the ordinary Morello, largely grown against walls, and as bush trees, and a third enormous Morello cherry. The first two are certainly perfectly self-fertile, even buds bagged and not hand pollinated mature fruit and apparently foreign pollen is of no advantage to these Morellos. Of this third enormous Morello cherry I have made no trial, and have only noticed it this autumn as a prize winner at the Wye Gardeners' Show. Morello is the only perfectly self-fertile Cherry I have experimented with, I think, but the John Innes Research Station has found the Late Duke cherry to be also quite self-fruitful.

KENTISH PRESERVING is described as somewhat larger and ripe about eight or ten days earlier than the Flemish, which it resembles. The colour of the fruit is described as at first flesh-coloured, then a clear deep red, and if allowed to hang it becomes very dark and almost of a black colour. The stone is larger than that of the Flemish, but like it, adheres firmly to the stalk, so much so that it may be drawn out, leaving the flesh entire. It is to some degree self-fruitful ; from five bags of unopened blossoms which were hand pollinated with their own pollen when the flowers opened, two fruits matured.

Twenty-fifth day. NOIR DE GUBEN. } are both found self-sterile at the
Twenty-sixth day. NOBLE. } John Innes Research Station.

These two varieties appear to be the latest of all cherries to blossom. I have not yet had the privilege of experimenting with them.

The average length of time that eight varieties of Cherry were in flower from first flowers to most of the petals fallen was 22 days, in 1909 on Mr. F. I. Neame's farm at Chilham, Kent. The trees were in full flower on about the 7th or 8th day after first flowers opened. Each variety was in full bloom for probably about a week.

The average length of time in full flower should be considered in conjunction with the relative order of flowering so as to plant varieties that are in flower at the same time together.

It will be realised from the perusal of the above few notes that a great deal more information is needed in order to be able safely to advise cherry growers as to what varieties to plant together in an orchard, and to correct mistakes by re-grafting with another variety. In Oregon some forty Cherry growers have co-operated with the State Agricultural College Experiment Station, the former giving all information they possess to the Research Station and encouraging pollination trials to be made in their orchards by the College. By which means results are being obtained quickly. See *Better Fruit* for August, 1923.

In closing, reference is due to the extensive and very carefully conducted experiments on cherry pollination at the John Innes Horticultural Institution, made by M. B. Crane and reported in the *Journal of Pomology* for April, 1923. My best thanks are also due to the following gentlemen who have most kindly allowed me the use of their cherry orchards for trials and given me assistance: Robert Amos and H. Stevens (Perry Court, Wye); F. I. Neame (Chilham); Alfred Amos (Wye); W. J. Jennings (Kennington); G. N. Sutton (Wye); Sir Walter Berry (Selling) and Capt. C. F. Hooper (Sheldwich).

The nomenclature of Cherries is very confused and the following names are applied to more than one variety: Amber, Baumann's May, Black Tartarian or Circassian, Cluster and Caroon. There are also three forms of Early Rivers grown and probably several of Morello Cherry.—Ed.

THE RESISTANCE OF APPLE STOCKS TO ATTACKS OF THE GREEN APPLE APHIS.

(*Aphis pomi, De Geer.*)

By A. M. MASSEE, F.E.S.

Once the varieties of so-called "Paradise" at East Malling had been sorted out, casual observation seemed to show that certain of these varieties, amongst their individual characters, showed a greater resistance or susceptibility to certain diseases and pests. This fact appeared so striking to Professor H. Maxwell-Lefroy, when visiting the Station, that he suggested to the writer of this paper that the material afforded a unique opportunity for studying how far field infections of this sort were merely due to chance, and how far there were in actual fact real degrees of resistance amongst varieties, and even individuals of the same species. It was therefore decided by arrangement with the East Malling Research Station, that a study should be made in the first instance, upon the attacks of the Green Apple Aphis (*Aphis pomi, De Geer*) upon the different numbered varieties of Paradise Apple Stocks. The writer was enabled to make this study as a Research Scholar of the Ministry of Agriculture during the years, August, 1921-1922—October, 1923.

I wish to take the opportunity of thanking Professor H. Maxwell-Lefroy for suggesting this work, and for general advice he has tendered me throughout the experiments, and to Mr. R. G. Hatton, for many suggestions from the horticultural aspect, many of which would otherwise have been omitted. The photographs were taken by Mr. J. Amos, to whom I tender best thanks.

1. The Problem.

The problem resolved itself more or less into the following propositions :—

First, as to whether such a thing as immunity to attack of *Aphis pomi* existed amongst these varieties or individuals, and if not whether there was any evidence as to degrees of resistance.

Second, whether the character of resistance was capable of being passed on from one generation to another of vegetatively raised stocks.

Third, whether, if a root stock resistant to *Aphis pomi* were obtainable, it would be possible to influence thereby the degree of resistance of the scion budded or grafted thereon.

Fourth, if degrees of resistance existed, whether this was affected by external conditions, such as soil, temperature, etc., or whether it was inherent in the individual plant.

Fifth, to ascertain if possible what were the causes of any such resistance ; whether it be due to morphological or other conditions.

Sixth, whether resistance to a particular pest in any individual plant implied resistance to other pests.

The Apple Aphis was chosen for the study because it is especially common on nursery stock, and seemed to give indications on the stool beds that it would be an excellent medium for studying the general problem.

The Green Apple Aphis has been recognised by fruit growers, as a troublesome pest for many years, being especially a great source of worry to them, on young fruit trees making good annual growth, and where the nurseryman is raising trees from buds or grafts. The usual method of controlling this pest is spraying. This is a costly method with this particular aphid, as the Green Apple Aphid remains on the host plant all the year round, and continued spraying may be involved. If immunity or a high degree of resistance of the plant were obtainable, this would obviously be the ideal method of pest control. If it were possible to select resistant stocks, and even resistant scions, and to perpetuate this advantage by raising vegetatively, and thereby introduce into the fruit growing industry varieties which will not be troubled to any great extent by aphis attack, it would be of considerable value to the industry. As a result of the above considerations a series of experiments were commenced in the Autumn of 1921, on some of the different " Paradise " root stocks grown at East Malling.

I. Natural Infections.

The first line of investigation was to study the casual infections in the stool bed rows under field conditions. Detailed records were taken in the three consecutive Autumns, upon the varieties of " Paradise," eighty stools of each variety being examined. The following Table indicates the percentage of stools attacked :—

		1921	1922	1923	Average %
Type I.	(Broadleaved E. Paradise)	96.25	71.87	50.0	72.70
,, II.	(Doucin)	88.75	60.62	78.75	76.04
,, III.	(Hollyleaf)	87.5	83.75	62.5	77.91
,, IV.	(Dutch ?)	59.37	49.37	36.25	48.33
,, V.	(Doucin Amélioré) ..	70.0	55.0	41.25	55.41
,, VI.	(Nonsuch)	66.62	58.75	52.25	59.20
,, VII.	(Old English ?) ..	88.75	86.25	28.75	67.91
,, VIII.	(French)	59.37	69.37	77.5	68.74
,, IX.	(Jaune de Metz) ..	28.12	23.75	37.5	29.79
,, X.	(unnamed type) ..	81.9	56.9	87.5	75.43

The Table as set out above shows with few exceptions marked consistency in the position as regards instance or degree of infection of each individual

variety (or type). Type VII. is the exception which in 1923 showed a high degree of immunity. This suggests the possibility that certain seasonal conditions such as temperature may to some extent qualify the character of resistance. As will be seen later, this possibility was somewhat strengthened by another series of observations.

From the earliest observations in 1921 it was noticed from the figures that there appeared to be several degrees of resistance amongst the varieties :— Malling Type IX., Jaune de Metz, Malling Type IV., possibly Dutch Paradise ? and Malling Type V., Doucin Amélioré, stood out as being the most resistant. The damage caused by the aphis was not so apparent on these three varieties, and later, a more detailed observation showed that the plant lice actually did not thrive to the same extent as they did, for example, on Malling Types I. and II. Type VI. (Nonsuch), Type VII. (possibly old English ?), and Type VIII. (French Paradise), might well be termed as intermediates between the very susceptible and resistant groups. Although it has not been possible as yet to obtain definite figures as to the rate of increase of the colonies on the various "Paradise" Stocks, as has been done in the case of the Bean Aphis by Davidson,* it was quite obvious that the rate was slowed down on certain varieties, and that the colony actually gave signs of deterioration. The individual aphids became small and laid no eggs as the normal colonies were observed to do. The varying types of damage caused upon resistant and susceptible stocks will be described in detail later, when the controlled infections are being considered.

Following on these preliminary observations seven varieties of "Paradise" chosen to include apparently resistant and susceptible forms, were examined as they stood in the nursery rows. It was found that in any particular variety, individual plants were infested with *Aphis pomi*, whilst other individuals remained unattacked. In order to test whether these latter individuals were actually immune or had merely been missed by chance, twenty-five infested plants of each of the seven varieties were selected, and were then tied to an equal number of non-infected individuals of the same variety. Within a few days, in every case some of the aphids migrated from the attacked on to the non-infested plant. As there was no evidence to explain why they were missed earlier in the season, this seemed to point to the fact that apparent immunity in the field was partly due to chance, a conclusion, however, not entirely borne out later under conditions of controlled infection. At the same time, the different degrees of resistance and susceptibility already referred to betwixt different varieties as regards intensity of attack were maintained. This experiment was repeated for two years with the same results. One further variety of stock was added the second year, and only helped to confirm results.

* Biological Studies of Aphis Rumicis. Anns. Applied Biology, Vol. VIII., No. 1, June, 1921.

II. Controlled Infections.

Following up these preliminary experiments, a considerable number of stocks some three hundred and forty in all, of some eight varieties representing both susceptible and resistant forms, planted in nursery rows, and under outdoor conditions, were tested for resistance by methods of controlled infection. These stocks were subjected to infection, of a known strain of *Aphis pomi, De Geer*. This strain has been kept going throughout all these controlled infections.

(*a*) *Method of Infection.*

All the stocks used were unattacked at the start and each individual stock was subjected to direct infection. Two apterous viviparous females were placed on the stocks, by means of a small camel hair brush. Experience showed that if the leaves or shoots carrying the specimens wanted for infecting the plants, were placed in a small box, a little while before using, the aphids would leave the stem or leaf upon which the colony had been established, and walk round the box. Thus the fear of damaging the mouthparts (stylets) in the progress of transference was greatly reduced. If the aphids had merely been brushed off the shoot directly on to the stock to be infected, there would have been grave risk of damaging those aphids whose stylets happened to be in the tissue of the plant at the time. In other words, the above precautions were taken to ensure that every plant should be infected with aphids capable of forming new colonies. Examinations were made once or twice weekly, generally twice, and records were taken as to the progress of the new colonies ; if the aphids had not established themselves on any particular stock, new aphids were placed upon these. Directly after each infection, the stock and prospective colony was protected by a muslin bag, to exclude all parasitic and predaceous insects.

(*b*) *Degrees of Resistance.*

Out of the three hundred and forty stocks of the eight varieties only one individual plant of Type IX. (Jaune de Metz) proved incapable of infection. This particular plant was to all appearance identical in health and other characters with the remaining forty-nine individuals of the same variety, yet after eleven separate infections the attempt to establish a colony was a complete failure. There was no obvious explanation for this. Though no other individual stock proved incapable of infection, the following table will show that the number of infections necessary to establish a colony varied very noticeably upon the different varieties. Type IX. (Jaune de Metz) and Type V. (Doucin Amélioré), two of those which showed resistance to casual infections in the field, required on the average five infections in order to keep a colony going. Every time the colony did less damage than on other varieties of Paradise.

A. B.

One Year Shoots of Jaune de Metz (Type IX.)

A.—Resistant Shoot. B.—Susceptible Shoot.

A. B.

One Year Shoots of Broad Leaved English Paradise (Type I.)

A.—Resistant Shoot. B.—Very Susceptible Shoots.

Unfortunately, there were no Type IV. stocks available to work with. On the other hand it will be seen that those varieties of Paradise showing susceptibility to casual infection, were almost universally infected after one or two infections. Two stocks, Types III. (Hollyleaf) and Type II. (Doucin), which had shown very ready susceptibility in the field were attacked almost 100 per cent. in the first infection.

Types.		No. of stocks used.	No. attacked after 1st infection.	No. attacked after 3rd infection.	No. attacked after 5th infection.	No. never attacked.
Type I. (Broadleaved Eng. Par.)	1921	50	43	47	50	—
	1922	50	42	45	50	—
,, II. (Doucin)	1921	50	47	50	50	—
	1922	50	44	50	50	—
,, III. (Hollyleaf)	1921	50	50	50	50	—
	1922	50	49	49	50	—
,, V. (Doucin Amélioré)	1921	50	20	27	50	—
	1922	50	10	37	49	—
,, IX. (Jaune de Metz)	1921	50	3	7	40	—
	1922	50	6	6	43	1
,, X. (unnamed Type of Par.)	1921	50	41	50	50	—
	1922	50	30	50	50	—
Northern Spy	1921	20	17	20	20	—
	1922	20	17	19	20	—
Crab A.	1921	20	14	19	20	—
	1922	20	19	19	20	—

In other words the different Paradise stocks fell into the following rough groups.

Apparently Immune :— 1 stock Type IX. (Jaune de Metz).

Resistant :— Type IX. (Jaune de Metz).
,, V. (Doucin Amélioré).

Susceptible :— Type II. (Doucin).
,, I. (Broadleaved Eng. Paradise).
,, III. (Hollyleaf).
,, X. (unnamed).
Northern Spy.
Crab A.

It will be seen how these results from different infections bear out the observations in the field.

From stocks used in this experiment it was, however, possible to select individuals from each variety which were considered to be the most resistant of their respective groups, by reason of the fact that they resisted infection longer, and were much less damaged by attack.

Figure 1 (a), represents Type I. (Broadleaved English Paradise) one of the stocks in that group which resisted aphis attack to considerable extent,

although leaf curl is noticeable; the stocks kept growing, the apex of the shoot being little affected. Figure I (b), represents two of the very susceptible stocks of Type I. (Broadleaved English Paradise). They are very dwarfed, and although leaf curl is not so prevalent as in the former, aphids are still breeding. Fungus damage is also evident. The three stocks mentioned above were all grown under identical conditions.

Figure 2 illustrates the Type IX. (Jaune de Metz). Although this type was less attacked than any other variety used in the experiments, it will be seen that degrees of resistance are very pronounced. Both shoots were grown under similar conditions, in nursery rows. Note that (b) the more susceptible of the two stocks, is not dwarfed to the extent as Type I. (Broadleaved English Paradise) Fig. 1 (b).

Figure 2 (a), Type IX. (Jaune de Metz) represents one of the stocks set aside for vegetative propagation, being one of the resistant series. These along with control plants, *i.e.*, those that had proved most readily susceptible, were pegged down and formed into stools, for vegetative propagation, the intention being to test the powers of resistance of the fresh generation of stocks raised vegetatively therefrom. As soon as growth was available in the following season, these new shoots from layered stocks were subjected to heavy and frequent infections of *Aphis pomi*. The object was to give the most severe test possible. The result was that the immunity of the single type IX. (Jaune de Metz) stock broke down. After many attempts a colony of aphids was established on this stock, the plant lice caused leaf curl, but eventually they died out, and the stool apparently did not suffer to any extent. The stocks on the resistant stools of Type IX. (Jaune de Metz), had a similar history. It was possible to establish aphis colonies, produce leaf curl, and blackening of the stem, but the stocks went on growing vigorously despite this, and by the end of the season, the damage caused by the plant lice was barely noticeable. Type V. (Doucin Amélioré) behaved in a very similar manner, but the damage was more noticeable, the stocks becoming a little dwarfed towards the close of the growing season. Curiously enough, the stronger growing types as I. (Broadleaved English Paradise) and Type X. (unnamed) did not as a group resist aphis attack to any appreciable extent. The stems very commonly became twisted, and the growths stunted. In many cases on these susceptible varieties, the leaves showed exceptionable damage. Practically every shoot was dwarfed, and as is common after heavy aphis attack, the fungus, Nectria ditissima (Tul), invaded the plants, and the tips of the shoots died back. These symptoms were far less frequent on Types IX. and V.

As a result of these drastic infections of the primarily selected resistant individuals, it was still possible to pick out from certain varieties of Paradise

one or more individual plants showing a greater measure of resistance than the rest of the group (Figs. 1 and 2).

The following were ultimately selected :—

9	stocks of	Type IX.
2	,, ,,	I.
3	,, ,,	V.
1	stock ,,	X.
2	stocks ,,	II.

These selected stocks had now shown in their own groups or type a comparative degree of resistance over a period of two years. It is obvious that if, as seems probable, it is possible to perpetuate this characteristic it would be a practical advantage in the nursery to be able to work with stocks showing a degree of resistance to attack. Another year or so should show how far such a selection is stable, and how far it is possible of development. Type III. (Hollyleaf), Crab A. and Northern Spy were tested, but in no case was there a single stock showing any degree of resistance.

III. The Inter-relationship of Root Stock and Scion in Relation to Resistance to Aphis pomi.

This part of the experiment was to determine whether a scion worked upon a resistant stock was in any way influenced by the stocks, to resist aphis attack, and vice versa. Bramley's Seedling, well known to be very susceptible to aphis attack, was worked on Type IX. (Jaune de Metz), this stock representing the resistant class. Bramley's Seedling was also worked on Type III. (Hollyleaf) one of the representatives of the susceptible class. In another series Type I. (susceptible scion) was worked on Type IX. (resistant stock), and vice versa, Type IX. (resistant scion) worked on Type I. (susceptible stock).

Sixteen trees of each of the four above-mentioned combination, making their maiden growth, were subjected in the last week in July, and in August, to direct infection. The results of the first seasons observations may be summarised as follows :

Sixteen Bramley's Seedlings on Type IX. (Jaune de Metz)—Susceptible after two infections.

Sixteen Bramley's Seedlings on Type III. (Hollyleaf)—Susceptible after two infections.

Sixteen Type I. (Broadleaved English Paradise) on Type IX. (Jaune de Metz—Susceptible after two infections.

Sixteen Type IX. (Jaune de Metz) on Type I. (Broadleaved English Paradise) —Resistant after two infections.

Up to the present as far as these trees are concerned there is no reason for supposing that if a susceptible scion is worked upon a resistant stock, it

will also become resistant to *Aphis pomi, De Geer.* Results showed that Type I. was just as susceptible as a scion as it was in the stool bed. On the other hand Type IX. as a scion was resistant to the same degree as in other experiments. Bramley's Seedling was equally attacked on Type IX. and Type I.

IV. Effect of External Conditions.

(*a*) *Soil variation.*

To investigate the possibility of soil affecting the stock in such a way as to make it become more or less resistant to aphis attack, a series of stocks were planted in various soils, and were subjected to direct infections. Three types of soils were used :

(a) Natural soil at the East Malling Research Station (a light medium light loam).

(b) Half Research Station soil and half clay.

(c) Half Research Station soil and half sand.

In these soils the following types of stock were planted under natural conditions :

Types I., IX., V., XIII. and Crab A.

From the beginning of the season these stocks were infected with *Aphis pomi.* During the first few weeks all the series were attacked to the same extent. The first noticeable difference was in July, when the series planted in sand began to grow more rapidly than those planted in clay. The stocks of Type I., which were planted in clay did not become so heavily infected as those planted in sand, or Malling soil. The growing point which is normally so easily checked on this variety did not suffer as usual. This suggests a possible correlation between growth at a particular period and resistance. This material is being kept for further observation. Apart from this one exception the different varieties of Paradise behaved as they had hitherto done under uniform soil conditions. It may be noted that for the first time a new stock, Type XIII., was included in all these series, and was demonstrated to be susceptible. It is just worth consideration that this is another of the vigorous group of stocks, so many of which, such as Crab A., Type I. and Type X., also fall into the susceptible list.

Varying Situation.

(*b*) *Stocks grown under glass.*

It was noticed in a water culture experiment under glass various types of apple stocks, viz., Types I., II., VIII., and IX., were severely attacked by *Aphis pomi.* Amongst these, Jaune de Metz, Type IX., appeared to be as badly attacked as any of the other varieties. To throw further light upon this interesting point, in 1922 three stocks of Type I., four stocks of Jaune de Metz, and three stocks of Type X. all in soil, were placed under glass. In the spring

of 1923 infections were started ; later on, all the stocks were found to be badly attacked and damaged independent of variety. Under glass Jaune de Metz apparently readily becomes infested, the stems twisted, and leaf-curl severe. The only apparent difference noticeable, was the fact that the aphids did not breed so quickly ; towards the autumn they died out before egg laying, whereas eggs were produced on Type X., the colony surviving sufficiently long. This result needs checking.

V. Possible Causes of Resistance.

(*a*) *Mechanical obstructions :—*

It was thought that possibly some light might be thrown upon the causes of resistance, if these should prove to be mechanical, by exposing various tissues. Several methods, such as wounding stocks by hard cutting, slitting epidermis, and severe root cutting, were undertaken on the various stocks of Type IX. The object being, to try to break down the resistance of these stocks. In no case was the resistance of these stocks altered by the treatment. The question of internal anatomy has so far not been dealt with.

(*b*) *Botanical and other varietal characteristics :—*

It seemed as just possible that varietal characteristics such as the pose of the leaf, giving more or less protection to the aphid, or its pubescence, affording more or less obstruction, might offer some explanation as to the causes of degrees of resistance. Take for instance, a susceptible and resistant variety of stock. The pose of the leaf in relation to stem of Type I. is described,* as " almost horizontal on stalk," and the surface " convex " with " many short hairs below." Whilst the description of Type IX. is " leaf somewhat erect on stalk, upright," " slightly convex, many short hairs below." In order to see whether colonies of *Aphis pomi* would settle down more comfortably on Type IX. the angle of the leaf pose of that stock was made horizontal artificially (instead of erect), by tying down with thread. In other cases the pubescence was rubbed off the under surface of the leaves, and the stem. After these operations, direct infections were made, but the operations did not seem to have the slightest effect in increasing susceptibility. Finally general observation did seem to show that a vigorous individual of a particular variety, did show more susceptibility than its weaker neighbours. Up to the present the causes of resistance are not apparent, though degrees of resistance are real.

VI. Resistance as a General or Particular Character.

The question naturally arises when varieties resistant to a particular pest appear, as to whether this resistance is confined to a particular pest such as *Aphis pomi*, or as to whether the resistant variety or individual, will maintain

* Hatton, R. G. " Paradise Apple Stocks." Journal R.H.S., Vol. XLII. Parts 1 and 2, 1917.

its resisting qualities before either associated species of the same family, or widely differing pests. The first light that was shed upon this subject in these experiments, was when Northern Spy stock, already proved to be immune to Woolly Aphis (Eriosoma lanigera. Hausmann), was included in the direct infections with *Aphis pomi* and proved readily susceptible. In recent work,* Staniland has grouped the varieties of Paradise according to their susceptibility to Woolly Aphis (Eriosoma lanigera. Hausmann), and it may be of interest to compare the degrees of resistance of the same varieties to the two species of aphids.

Aphis pomi, de Geer.		Eriosoma lanigera. Haus.	
Susceptible.	Resistant.	Susceptible.**	Resistant.
I.	—	I. v.s.	—
II.	—	II. v.s.	—
III.	—	III v.s.	—
—	IV.	IV. s.	—
—	V.	V. v.s.	—
VI.	—	VI. v.s.	—
VII.	—	VII. s.	—
VIII.	—	—	VIII.
—	IX.	—	IX.
X.	—	—	X.
XII.	—	XII. s.	—
XIII.	—	—	XIII.

It will be seen at once that on the whole the similarities and exceptions are almost equally divided. In seven cases out of twelve, varieties of Paradise show similar degrees of resistance or susceptibility.

It is encouraging to find that in at least one case a highly resistant stock to one species has proved highly resistant to another, in the outstanding case of Type IX. This may be pure accident, on the other hand there may be a single underlying cause making for a common resistance to both species.

Finally, a group of stocks from resistant and susceptible varieties were selected, and the leaf eating weevils (Phyllobius oblongus. Linn), were placed in confinement on each plant. The damage caused by the Weevils was two-fold. They attacked the young buds in the spring, and a little later on they attacked the mature leaves. Both the resistant and susceptible varieties were attacked, the buds and leaves of the aphis resisting group being as badly attacked as the group susceptible to aphis attack. When the Weevils survived they apparently thrived equally well on both varieties. It therefore seems clear that there is no correlation between resistance to *Aphis pomi* and to Phyllobius oblongus, if resistance to the latter actually exists.

* Journal of Pomology. Vol. III., No. 2, April, 1923.

** The susceptibles to E. lanigera are divided into two groups, s. and v.s. Those marked v.s. are in the more susceptible group.